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INTRODUCTION.

The fourth volume of the Transactions of the American Institute of Electrical Engineers is the first that has been issued containing the papers presented at special meetings and the ensuing discussions. The rapidly extending field of electrical industry has developed a corresponding growth of scientific electrical research, and acting upon the supposition that beneficial results would follow a straightforward attempt to encourage the interchange of ideas upon the electrical questions of the hour, the Council has, during the past year, appointed more frequent meetings, the records of which are now published in full. The good effects of this policy have been manifest, not only in the steady numerical growth of membership, but in the widespread recognition of the scientific standing of the Institute as a body. Some of the most distinguished electrical engineers of the world have appeared before it, and the thoughts of its members have been stimulated to renewed activity by the information elicited during the various discussions which have taken place.

As has been previously announced, the full reports of meetings are to be hereafter published in separate numbers during the month in which such meetings are held. This will furnish a most desirable channel for the presentation of important electrical papers and their intelligent discussion, which is offered by no other society in America.

It will be the continual aim of the Council to use all possible means to further the objects of the Institute as outlined by its founders in 1884, namely: "to promote the arts and sciences connected with the production and utilization of electricity, and the welfare of those employed in these industries, by means of meetings for social intercourse, the reading and discussion of professional papers, and the circulation, by means of publications among its members and associates, of the information thus obtained."

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AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

SPECIAL MEETING.

SUBJECT: INCANDESCENT LIGHTING FROM CENTRAL STATIONS.

June 8th, 1886.

The meeting was called to order at the Mills Building, 15 Broad Street, New York, by the President, Mr. Frank L. Pope, at 8 P. M., who announced the subject for discussion with the following remarks:

It gives me very much pleasure to see so large an attendance on this occasion, the first of our monthly meetings, and it affords us excellent encouragement as to what we may expect in the future. It is an old maxim that we should always attend to business before pleasure. I think we have put in an hour of good solid business, and I had hoped that we should next have the pleasure of listening to a paper on the subject of Incandescent Lighting from Central Stations, by Mr. H. M. Byllesby of the Westinghouse Electric Company; but Mr. Byllesby has unfortunately become entangled in a complication of business that has come up during the past few days, which has occupied his time so fully that he is unable to be present, and in order, therefore, that the meeting may not be disappointed, we have asked Dr. Otto A. Moses, to favor us with his presence this evening, and to make a few remarks on the same subject, with which he is, as you all know, very familiar. Dr. Moses has very kindly responded to our request at considerable inconvenience to himself, and will now open the discussion.

DR. MOSES:—Thanks, Mr. President and gentlemen, for your consideration and this kind reception. It is, indeed, a great surprise.

I am asked to say something about incandescent lighting from central stations. The subject is a vast one, and I do not know from which point to attack it. Its ramifications have extended so far that if I start to treat of any branch and follow it up, I am sure to be felt along the line by some one present. I do not know in which direction the majority would have me proceed, but since we are to have a general discussion on my remarks, it would be well to introduce a variety of topics each forming part of the central subject which is: Where are we to locate central stations for all kinds of electric distribution, and how is electric energy to be generated, stored, and expended in them?

The central station of to-day is a very large and cumbrous arrangement. There are many engines in rapid motion and exposed to many dangers of interruption. There is an air of gloom and anxiety on every face; the unseen tremendous power not always under control, which is consumed at uncertain times and at invisible points, may be made to react at any moment with destructive energy. A central station ought to be in such a position that no accident could possibly happen to it—earthquakes, of course, excepted. I would have a central station put somewhere, where the fuel would be at its cheapest, labor very cheap, space costing next to nothing, and where your supplies would be without fail. Imagine to yourselves a central station in this city, with a break in a water pipe leading to it, or a fire next door, and the rafters and bricks tumbling in on the boilers; or a gas explosion in the street, and a main electric feeder, supplying two-thirds of a district, bent and twisted into contact with an outer casing; imagine a hundred accidents that are likely to occur. Those things ought to be avoided; and for that reason I think we ought to say that henceforth our central station should be extra-mural; carry it as far away from the city as you can, into the region of the fuel supply, and when you have it there, you should be able to distribute power from that point to other cities than the one from which you carry the capital to build it with, analogously to what is done with natural gas and petroleum. Suppose, for instance, you should go out to some of these large waste coal heaps in the anthracite regions, and locate your central stations. The question then arises how are you going to get your current down conveniently? That is a point which I would like each one of you to seriously consider, and then to bring some fresh thoughts concerning it, to the next meeting. It is necessary that we should work out in various directions in solving this problem. First we must have a means of storing electricity. Now don't laugh: it is absolutely necessary that we should have the means of storing electric energy after it is produced. That subject has fallen somewhat into ridicule, very much as did the incandescent light in 1878. People then looked askance at the great cumbersome lamps, with large carbons and blackened globes, and said to themselves, "there is nothing in this." But, during a period of a year or so, while no one seemed to pay any more attention to the subject, the incandescent light gradually evolved and under the glow of light shed upon us at this moment you see what it is to-day. So, I say, we must look then to the secondary battery again. There is no getting around it. I do not see any way of avoiding starting from a fixed point. Archimedes wanted a fixed point; we begin every geometrical demonstration from a point, and if I should wander from the point, please, Mr. President, call me to order. We have to go then to the source of supply for fuel and transform it into electrical energy and store it. We must have it where we can make it available. But for the present there must be an intermediate link forged in our chain in order to transform into electricity the sun heat stored up for future use in the coal. We have got to bring it into the form of potential energy, store it, and then distribute it. There is no trouble in the world in handling any Rhumkorff coil. Why, you would let your little child put on a Geissler tube and finger around it—not much danger there! It is a bugbear! People are scared at the handling of currents of enormous potentiality. I say, don't touch them; that is all. Let this current be as strong as you please, and it is harmless, if you don't touch it. Do you think I am going to tremble and gnash my teeth because I happen to know that there is a subterranean fire underneath us so hot that it makes a man shiver to think of it? Wait till it comes. Wait till we have a Cotopaxi or Chimborazo open on Long Island somewhere. Let us wait. I think I could count on my ten fingers the number of accidents that have occured thus far. And yet, like sweet morsels between their teeth the reportorial tongues roll these things about until every newspaper in the land speaks of death and desolation from electrical currents. That sort of thing, you know, makes a popular prejudice, and prejudices are always pandered to. But let us cut loose from prejudices. Let us go back then, I say, to the use of a very high potential, in order to economize in our conductors, and let us bring our electricity to some point where a careful man would handle it and distribute it without danger to the consumer. Do you think they would put a drunkard behind a bar to dispense liquor? Not a bit of it. So neither would a reckless or careless man be selected to superintend the distribution of great electrical currents. But we should cause the distribution to take place as closely as possible to the point of consumption; and I predict that the source of supply will be the coal bed itself. However, for that consummation we will wait a little while; I think I will be still grayer before it is effected. But it is not impossible even now. And, just there, I would like to call your attention to some points which I would have you carry away with you for reflection. If you take a gas flame and examine it you find something which to my mind's eye seems much like the vibrating carbon in this incandescent lamp. Chemically it is identically the same as that. I have analyzed them both. The temperature at which they are made is just about the same; and since their chemical composition is exactly the same, I ask wherein do they differ? They differ only in this, that the carbon of the lamp stays when you put your thumb on it; the other is like the Irishman's flea, although it gives light from the flame it is gone when you put your finger on it. Now, we have a current passing through that loop, and an electrical current is setting the carbon in violent motion—that is light. If I were to take a current shunt from that incandescent loop as you have all done, you would be able to measure the strength of it, peform various experiments with it, and the lamp might go on shining, even though you did take a shunt from it. Why, gentlemen, I ask in all earnestness, can't you take a shunt from a gas flame? There is something for you to chew on. You can get thermo-currents from a gas flame, as is well known, by heating in it joints of dissimilar metals. Those currents you may tell me, are produced by chemical action of these conductors at their points of contact—very easily said. But we don't see any very great disintegration of the metallic conductors, and we get comparatively large quantities of current, sufficent to deposit more than the weight of the metals at a distance, by chemical action. There is to be sure, the same source of energy there in both cases—that very convenient "heat" which covers a multitude of sins nowadays. Heat meets us as an answer at every turn. It is supposed to be the heat that generates the electricity in the thermo-current and it may be said because we can easily transform one force into another, therefore the heat in the case of the thermo-current generates electricity. Why, I can as readily ask, may not that thermo-current be the result of chemical action and heat combined? Is not chemical action there in that gas flame as the result of the heat? And why may not the source of electricity be the chemical action alone, and the heat be the effete electrical product? If you take two dissimilar metals and put them in the flame, one in the point of the flame and one in the interior, you get a current; but the action ceases very soon. You take joints at the end, and you get a continuous thermo-current there. What is the difficulty in the first case? Why can you not draw off quantities of current commensurate with the energy expended in the burning flame? Now here is the direction for you to look for new and startling results. You have got in the carbon of a gas flame a constant source of energy, and, if I may use the expression, a metal to be consumed. That carbon is consumed in the gas flame. There is a constant oxydation of the carbon going on. In the same way you consume your zinc in the battery by oxydation. Why have you not then, there, currents commensurate with the chemical processes that are going on? They must be there: they are there. Recollect the time that it took Faraday to discover his spark. It is very easy to find the spark now-a-days if you go around any central station for electric lighting. Now, then, this is the direction in which you have got to look for future sources of current, and it is in the coal field where we will have to make the transformation. Now, then, when you have got the combustion of carbon and oxygen, the carbon and oxygen being unlimited in supply, you have all that is necessary to produce current without end. If the combustion can be made to go on in the mine itself, you have got an endless source of electricity, without the necessity of gathering and transporting your supplies. Such currents may be of exceedingly low potential; but that is nothing. In the Bank of France to-day they are working arc lights from thermo-currents of low potential. There is no reason why thermo-currents cannot be used for extensive systems of collection and distribution, but, I say, generate your thermo-currents in the mines, where they will cost least to produce. Now, then, you have got to carry your thermo-currents from the mine, say, to New York. Well, to do that requires a current of very high potential. Now, in the present state of the art, to carry a current of high potential over the main wire, you must have good insulation, and the very best insulation for your dynamo machine, for, if sparks pass between the adjacent turns of wire, you have to unwind your dynamo machine to get at the damaged part. Some day you will be able to discard moving machines as a source of current electricity. What are you going to do with your dynamo machine in the mean time, you ask. I say for the present use your dynamo machines, but put them in the mines, right next to the coal. Burn your coal in the mine; build your boilers there. You need not carry your coal very far. Send your currents to the surface a distance of a few hundred or a thousand feet. Store your currents there. Now, for this use you can employ the simplest kind of dynamo machine in the world, furnishing currents of ½, 1, 2, 3, volts. What do you want with a current of a hundred volts in any dynamo machine. Carry your currents up to the surface with the lowest potentials, the largest conductors, the least resistance, and then store. Store what? Your surplus energy, keeping it at low potentials until needed, when, as in the thermo-pile, you may couple them up to 1,000—10,000 volts and bring your current into the city. Use, if you please, a Gaulard-Gibbs arrangement. Let that transform currents for you. What is the use of handling them? Take them off by induction. Here then, gentlemen, we have a brief sketch of a feasible method of bringing currents in unlimited quantity to central stations. First, burn coal, in the mines, make steam cheaply to drive large engines situated near at hand; these to turn dynamos of large size and producing currents of exceedingly low potential. Transform your currents at the surface. After their energy has been stored in secondary batteries you can couple them up to any potential you please. You can use your current when you please and as long as you please, or you may keep it stored. The loss is not more than from one to two per cent a day. That seems to me to be for the present an adequate method of obtaining a source of electrical supply of absolutely unlimited quantity. When you get it here you can redistribute it and retransform it. You will thus be able to generate electricity much cheaper than by bringing the fuel to produce it to the point of consumption, forcing it through large pipes, if it be natural gas, or flowing it through like petroleum, or carrying it as coal on railroad cars. Having brought you thus far, I will stop and let somebody else take up the current for distribution. (Applause.)

DISCUSSION.

Mr. Wetzler:—I would like to ask Dr. Moses what he considers the limit of potential which he would use in such a system?

Dr. Moses:—I would not hesitate to use 10,000 volts.

Mr. Wetzler:—But you would want some one other than yourself to handle it.

Dr. Moses:—I meant that I would not hesitate to send a current of 10,000 volts but not to receive one. But, joking aside, if you insulate you can very successfully use small wires and obtain as perfect insulation as with a cable.

Mr. Wetzler:—So your limit is 10,000 volts. I had occasion the other day to figure out a problem in which it was required to transmit 50,000 horse power to a distance of fifteen miles. I calculated that I would use 3,000 volts, and that the conductor would cost me over $5,000,000, since fifteen miles would require thirty miles of conductor, hither and thither. It requires about 16,000 amperes at 3,000 volts to give me 50,000 horse power. Allowing a loss of 33⅓ per cent. in transmission I had to have 50,000,000 volts.

Mr. Rapieff:—Insulation of the 10,000 volts is not as easy a matter as you think.

Dr. Moses:—What very large Rhumkorff coils have we here in the city—about what potential—do you recollect?

Mr. Rapieff:—I don't know; nobody knows.

A Member:—Thirty thousand volts.

Mr. Rapieff:—Is it difficult to get any insulator so perfect that there is no spark at all?

Dr. Moses:—Yes, although it is not the fiftieth of an inch in thickness.

Mr. Rapieff:—May be not; but you must also take into consideration the distance in this case; that is the distance of the conductor from another conductor where the spark can pass, or else it is the greater distance between the spark and the free air.

Dr. Moses:—If there be no discontinuity, why should the spark pass?

Mr. Rapieff:—Sometimes it is necessary.

Dr. Moses:—I do not see why it is necessary. As I say, I do not want to receive the current from a make-and-break arrangement. It is possible to make such machinery that there will be no necessity at all for the breaking.

Mr. Rapieff:—I do not say that it is impossible; but at the present moment I think that it is rather impracticable.

The President:—It would seem that this question of the distribution of electricity is going to depend very largely on how high a potential we can use or can practically handle. I do not see why we should necessarily set that limit at 5,000 or even 10,000 volts, nor does there appear any good reason to suppose that we may not be able to handle 100,000 volts ten years from this time as easily as 1,000 to-day.

Mr. Rapieff:—But suppose you look at the question from the present state of industry.

Dr. Moses:—When I called attention to the production of electricity simply from the coil I had no right perhaps to argue as I did; it was simply an hypothesis; but judging from the way in which you listened you seemed to think it possible and yet the transmission of considerable currents has not been accomplished, but the question is, may it not be possible at some early day to so insulate the conductors and isolate the currents so carefully that there may be no danger whatever.

The President:—I think we should be surprised, if we knew how high an insulation we have already obtained in the Rhumkorff coil. A way was found to accomplish that; why may not a way be found also to effect the insulation hereafter in conductors carrying large currents of tremendously high potential? It was not until Ritchie, I think, invented the so-called Rhumkorff coil that the solution of the problem was found; it was not easy to find. Page did not succeed in making such a coil.

Mr. Wetzler:—Well, Dr. Moses refers to some experiments made in France. They worked at 7,500 volts and yet they got a spark between the wires of their machines and ruined them. If 7,500 would do that, what would 10,000 do?

The President:—It does not appear to me that it is a question of insulation of the machine, but of the insulation of the wire, and the machines must be eliminated from it and all fixtures of every description as far as possible.

Mr. Wetzler:—Assuming that it is a question of insulation of the line wire, you have to consider the practical question of the cost of insulating such a line, when it would cost $5,000,000 for a copper line—just plain copper—at 12 cents a pound. I figured it a long while ago.

Mr. Shelbourne:—If I understand the question, I think the induction apparatus was built by a gentleman in London—I believe that is the largest induction coil that has been built. It contained 150 or 160 miles of about No. 31 Birmingham gauge wire. In that coil the secondary is so put up that it can be divided into four parts or three parts; and the end wires are two sizes larger than those forming the middle portions, and as the wire comes to the end of the coil it is made larger so that the intensity of the current should not destroy the wire; it safely carries the current and then passes out from the coil through the insulated openings. I believe there are very effective means of insulating the wires, so that the current does not escape materially. The base is made of ebony or hard rubber.

The President:—I am inclined to think that we shall depend very largely on air for the insulation of these high potential lines; and not attempt to put them underground, but suspend them on poles on a strip of land, a right of way which we will buy and own as a railway company does, and if any body goes on there, and trespasses or meddles, he is a dead man; he takes the risk.

Mr. Lockwood:—That is a good idea.

The President:—A strip of land 100 feet wide for a right of way from here to Boston could easily be obtained. It is not necessary to follow any particular grade; you can go where you please through land of little value. You can keep trespassers absolutely off it, protecting it at the crossings, as you now protect a railroad. That has been a favorite idea of mine for a long time. Now when it comes to insulation, if you can cut out all trees and obstructions without interfering with anyone else, it is a simple problem. The air is a sufficiently perfect insulator, and hence it becomes practically a question of insulating the supports. All the leakage that occurs, takes place practically over the supports and very little, if any, through the air, no matter how foggy it is.

Dr. Moses:—Those currents however, being of exceedingly high potential, you might be compelled to insulate that wire and protect it from the rain.

Mr. Lockwood:—If I understand rightly, Mr. Wetzler's objections derived from the results he has come to after so much figuring, the chief obstacle to any such arrangement as Dr. Moses has suggested—and it must be remembered he suggested something to come hereafter—is the cost. Now, if such a state of affairs should occur, and I agree with Dr. Moses it doubtless will, I am not prepared to say how near in the future—the cost will be comparatively a trivial consideration—that is, the cost of carrying wire and the plant; in that, as in every other exploitation of electricity, the cost will ultimately fall upon the user. (Laughter.) I beg your pardon, gentleman, I did not intend to say anything funny at all, if you would hear me out, please. I was going to say, in that case, there would be a sufficiently large number of users to divide it up thoroughly.

THE PRESIDENT:—I might suggest that the cost in these enterprises sometimes falls on the stockholders rather than on the consumer.

MR. LOCKWOOD:—It would undoubtedly at first fall on the stockholders or bondholders; but the thing could be probably capitalized at the start, so as not to fall on the original bondholders or stockholders even; that might be well distributed.

MR. MAILLOUX:—Mr. Lockwood happens to be connected with a company which finds it practicable to make the user pay; but sometimes it is not practicable.

MR. LOCKWOOD:—I leave it to the gentlemen if the consumer is not the one who eventually pays for the electric light.

MR. MARTIN:—In that problem of carrying the power from Niagara, the cost figured out for the raw copper of the conductor, without insulation or anything else, sums up over $5,000,000. I believe Mr. Wetzler's figures are correct.

MR. WETZLER:—I was led to undertake the problem by a consideration that they were going to build a canal from Niagara to Lockport, and it struck me the thing might be done by electricity somewhat cheaper; but I concluded after figuring it out, that they had better build the canal.

THE PRESIDENT:—What we have to consider, is the comparative cost of carrying energy in its different forms, whether in the form of oil in the pipe; whether in the form of coal transported over a railroad, or in the form of compressed fluid carried in a pipe; or electricity in a wire.

MR. MARTIN:—Well, we figured 3,000 volts. Sir Wm. Thomson tells us 80,000 can be used, and there is a wide difference. We took it at the practical figure of what we knew was being done at the present time.

DR. MOSES:—Let us make a big jump then. I recollect, it is not more than five or six years ago when the carbons of incandescent lights had about two ohms of resistance, and somebody at a stride went up to about 200. Well, it was only a mere matter of degree. Now, while we are figuring on this thing, and we are going to use air insulated wires and going to have death lines, which I think is an admirable idea and will one of these days prevail; why not make a jump to 100,000 volts. All we have to do is to put the current on and take it off that wire by induction and not touch the wire while doing it.

A MEMBER:—There would be no difficulty if a line was left uninsulated provided the supports do not leak. You can carry a million volts; it would not inconvenience you in any wise. Why could'nt you use the total horse power of Niagara Falls instead of coal power?

DR. MOSES:—You have simply to tunnel the falls above the rapids and put in turbines; then you have practically unlimited power.

MR. MAILLOUX:—If a system of induction coils were used one at each end, there would be a difficulty in regulating so as to keep the amount of the energy used proportionate to the amount of energy expended; in other words, to make the supply equal to the demand at all times. Now would we not comes across a difficulty with induction coils, similar to what has been met with in the machine of the Lontin type, for instance, which consumed more energy at the time they were opened than at the time they were closed?

THE PRESIDENT:—You will meet with exactly that difficulty. It is probably not an insuperable one, but it raises a very difficult question.

MR. MAILLOUX:—I think if we have a system of induction coils at either end, and then take the energy out again at the other end, as an induced current of lower potential and larger volume, we would necessarily meet with that difficulty, that as the amount of energy required would depend upon the amount used at the second secondary coil, then there would be no means of regulating that energy so that it would be always adequate. It strikes me I could conceive of a time when there would be more energy called for than the circuit would furnish, and at another time the circuit would be wasting energy, only a small portion of it being utilized, so that we are brought again to the storage battery pure and simple as Dr. Moses first spoke of it. It strikes me that we must have not only a means of transforming that energy but of storing it at the point where it is to be utilized because it can be stored against all sorts of contingencies. If not used to-day it will be to-morrow and the generator can be working constantly twenty-four hours a day, or as nearly so as possible, while we all know that we could not expect to have it consumed at that rate throughout. Consequently we will notice that energy transmitted at a smaller rate would be able to do heavier work because the time of charge can be so much longer and the charge is continuous.

Dr. Moses:—A storage battery could be devised that would do away with the ordinary secondary battery. If you are using currents of enormously high potential, you could use those currents for the decomposition of water. Here would come back one of those old prejudices. You recollect that with the first dynamo machine, as Mr. Dumont once told me—he told me the whole history of it—they wanted to decompose water, and, of course, they got over it by the use of light direct. But it is too expensive? In this case, where you have an unlimited supply, sacrifice what is necessary for the purpose and store your energy by using currents of enormously high potential and use it to decompose water which would compress itself almost to the liquefaction of the gas under currents of high potential.

Mr. Rapieff:—Water is a very good conductor for currents of sufficiently high potential; but you would have to keep preparing distilled water.

Dr. Moses:—You could have energy enough in a barrel of water to run a city of 100,000 inhabitants—a barrel of absolutely pure water in a surrounding case, lined, if you please, with glass, or platinum, it would be possible to store your energy. Why not?

Mr. Rapieff:—If you do not care for the expense, you can do anything, of course.

Dr. Moses:—The expense would not be so vast. All you have to do is to make your receptacle large enough and strong enough.

Mr. Mailloux:—How would you utilize your energy stored?

Dr. Moses:—By combustion.

Mr. Mailloux:—That would bring us back again to the gas secondary battery.

Dr. Moses:—That is so. Why not use the gas direct?

Mr. Mansfield:—I was visiting a gentleman recently who related the following incident: The wire passing over the top of the batteries became disconnected resulting in a slight flash. There was a little overcharge and the gas accumulation on the top of his batteries exploded and the fright it gave that man convinced him of the financial possibility of the storage of considerable energy in that direction, and it is very strange that the same point should be brought up this evening.

Dr. Moses:—The gas battery is a very economical battery. Glass tubes are cheap and strong. There is no reason why you could not make an unlimited amount of them.

Mr. Shelbourne:—Gentlemen, I have not figured out any of these problems, but a little common sense leads me to the belief—without saying that I have got an opinion—that the interest on $5,000,000 would buy and transport all the coal that was wanted for that horse power—the fifteen miles and put it down without any further expense.

Mr. Wetzler:—Provided the coal was at the source, at that distance fifteen miles.

Mr. Shelbourne:—True, but instead of bringing the currents of electricity wouldn't the interest upon the money required to build such an equipment, buy the coal and bring it here to New York city and then build the station in the outskirts or on a floating structure in New York harbor for your use?

The President:—As far as the problem has been developed at present, of course it would. What we are trying to get at is to ascertain if there is any possibility of carrying our energy in the form of electricity more cheaply than we can do it any other way. We do not know how to do it yet. We hope to find out if we work at it long enough.

Mr. Lockwood:—Mr. President, it is quite well-known to us now, whatever it may have been before we met here, that lighting is the oldest profession in the world. Dr. Moses gave us that information.

Dr. Moses:—I was there.

Mr. Lockwood:—He said that the first words uttered were, "Let there be light." He now tells us that he was there, and, since matter is indestructible, there is no doubt that he was there—at least in the form of protoplasm. He proceeded then to make further remarks and quotations from a book I highly respect and before he said what he was going to say, I was under the impression that he was going to give as a reason for his presence here this evening, "And the Lord said unto Moses." It seems not. But to whatever beneficent spirit we owe the presence of Dr. Moses here to-night, I am sure you will all agree with me that we have been instructed and interested by what he had to say and we have the more reason therefore to congratulate him and ourselves in that his remarks seem to be entirely unpremeditated. He has given us great food for thought. I confess that I was unusually interested in his remarks and I propose to test them later, perhaps in the hope that I may be the fortunate one who may transform electrical energy direct from coal.

Dr. Moses:—I hope so.

Mr. Lockwood:—It seems to me that the thoughts of Dr. Moses and of every gentleman that has since spoken are, after all is said and done, much in the same spirit. He did not say, as I understand it, that the happy time that he referred to was now or next year or next century, but that it would surely be. Gentlemen who have spoken since, agree that the chief obstacle is expense. We all agree that things which are difficult are not necessarily things which are impossible. Thirty years ago many of the operations of electricity, which are now household words, were considered to be impossibilities. When Mr. Rapieff, who honors us with his presence this evening, first put his lamp in the *Times* office, he did not expect to sit with us at this board in a room lighted by means of this incandescent electric light. When Mr. Edison transformed the lower resistance cylinder into the higher resistance filament, he did not anticipate that within three or four years half a dozen other gentlemen would have anticipated him in that achievement and would all have been the first inventors of the high resistance filament, and I don't know, I confess myself, where the point of low resistance stops and the point of high resistance begins. But, perhaps, some of us may, and, therefore, I say that the remarks and opinions of every one that has spoken yet, seems to be very much in the same line, except in the degrees.

Now, speaking of secondary batteries. The gentleman who spoke last regarding secondary batteries, mentioned about the gases playing over the surface during the chemical operations of the battery; and it occurred to me that the flash he spoke of might have been the flash due to the operation of the electrodes at the time. I do not know that that is the case. I merely make the suggestion.

I was very much pleased also to hear Mr. Wetzler's statement as to expense. It shows that he looks at things from an economic point of view, and in their right light, and is not dazzled by the way that electricity frequently throws a glamour over all our eyes, so as to make the smallest things done by electricity seem great, easy and good. The late Cromwell Fleetwood Varley used to hold it as a maxim never to do anything by electricity that you could as well do by hand, and it is a first class maxim whether applied to telephony, telegraphy, or lighting. If we could make lights as excellent as these without going through the formality of dynamos and wires, it would be better, provided we could do it cheaper. But the maxim is good any way.

Mr. Mailloux:—I would like to hear from Dr. Moses, as he is an authority on incandescent lamps, what his opinion is as to running incandescent lamps either with high or low potential.

Dr. Moses:—As far as the use of low resistance lamps is concerned I think that when you consider the cost of the conductors that for a series arrangement they are unsuited, so that I do not see any advantage in them whatever.

Mr. Lockwood:—But one will light a room fairly well if it has one of these two powers.

Dr. Moses:—It depends on the size of the room. But the difficulty about them is the machinery that is necessary. The problem that every inventor ought to set before himself, and he should repeat it after every thought, is: Can I simplify this thing? And when he gets it down to such a condition that it cannot be simplified any more, then it is perfect. You cannot have a simpler arrangement than a carbon loop; and when you have got that and a constant current, why must you interpolate machinery in it anywhere? Let the machinery do its own regulating and the lamp do its own regulating. You hear people frequently say, "Oh, if we had a lamp that we could turn down!" What is the use of that? In the day-time we don't think of turning out the sun, though we have a great deal more light than we need. Expend your ingenuity on devices by which you can have as much light as you want at any time. Now, as far as the use of incandescent lights on circuits is concerned, there is another problem that ought to be studied. It is very near solution, though, I think, now. You may hear more of it later. You can use currents of any potentials for running incandescent lamps. The same conditions hold as for running currents, as we were discussing a while ago. All you want is proper insulation. If you examine one of these lamps—I don't suppose Mr. Edison would object to my advertising his lamp a little more than I have done

—(illustrating). If you examine that lamp, you will find right here is a metallic cap. Now if this was a current of about 10,000 volts and my shoes were wet and there was a leak on that line and I touched that cap, how far do you think that I would jump? —that is if I could jump? Now you see, that is a very ingenious arrangement, but it is also a very unsatisfactory arrangement if you use a lamp with a current of 1,000 or 2,000 volts—very inconvenient. Therefore, you do not see these lamps in series. You do not see them on currents of very high electro-motive force. Now that is a mere mechanical problem. It is a question that has not yet been touched on—series illumination. I could use a current of 100,000 volts—why not?—by a proper insulation. Mr. Edison does not choose to use a current of more than 110 volts, because he says when you are putting on and off lamps, there would be great danger in the use of a current of very high electro-motive force; but if you insulate properly and have no contact there for making and breaking the currents, there is no reason why you should not use a current of 5,000 volts on incandescent lamps. There is a nut for you, gentlemen, to crack.

Mr. Lockwood:—Isn't there one objection to high resistance incandescent lamps—the necessity which arises of using large mains? Otherwise you are just as likely to have an incandescent lamp of your leading wire, as you are of your lamp itself.

Mr. Mailloux: And using shunts.

Mr. Lockwood:—Yes.

Mr. Mailloux:—Isn't the three wire system equivalent to the serial system for all purposes?

Dr. Moses:—To a slight degree.

Mr. Mailloux:—Couldn't that be extended further?

Dr. Moses:—No, it wouldn't be advisable. You want as constant an electro-motive force as you can have, even on a three wire system.

Mr. Mailloux:—Couldn't the same arrangement be applied to ten wires, with a dynamo between each, and have ten lights in series in the circuit, and use ten times as high electro-motive force as you are using now?

Dr. Moses:—Still it wouldn't be so practical, where you are using more than two conductors, you are increasing the difficulties very much indeed.

Mr. Mailloux:—It occurred to me that in streets like those we have up town, parallel to each other, large conductors might be run on the two outside avenues; in the intermediate avenues we could run small conductors; then have them all branch through from each other by means of wires, running through the numbered streets, as may be necessary and those wires to be used only for equalizing the difference of potential between those blocks. It occurred to me that in this way you might use a higher potential with a small amount of copper perhaps. I don't believe myself that the figures will show as large an economy for the three wire system as has been claimed. Yet, at the same time, I recognize that the system might be made to give a larger saving and that smaller conductors could be used than where you have to run a parallel or multiple system all through.

Dr. Moses:—That is so; it would be worth trying. Even with these currents they do not regulate themselves; that is all done by hand.

The President:—I would like to ask Dr. Moses if it is not the case that the larger the number of lamps in the system the less trouble regulating it by hand—the less the particular attention of the engineer or any other person who has charge of it is needed; in other words, doesn't the larger number tend to make the changes in the consumption of current very gradual?

Dr. Moses:—Yes, that is true; and once you get your brushes working well, and avoid any of these effects Mr. Hughes speaks of in his recent paper, you work along very nicely; but if some careless man skips a brush and gets on the wrong block, and gets some of these extra currents in, all that tends to disturb things, so that it is all very good when you have three wires, but it is very complicated with four; it has got to be very nicely balanced.

Mr. Mailloux:—Would it be practicable at present to make them so as to work with high potential—say two or three hundred volts?

Dr. Moses:—Yes, you can make incandescent lamps to run at 500 to 1,000 volts. You see the limit is this—the length of the incandescent conductor.

The President:—There is now working in London a pretty large installation of incandescent lamps in the establishment of Whitely, "the universal provider," which is worked direct by an alternating dynamo—I think it is a Ferranti. I was told, when in London, a few months ago, by some of the electricians there, that the result in that establishment had tended to show that the life of the lamps was longer under an alternating current than with a direct current.

Mr. Rapieff:—The experiments of Siemens also proves that alternating currents are better for the life of the incandescent filament, but I don't think it is correct.

The President:—You have perhaps noticed that the same claim is made at the establishment of Ganz and Co., electricians in Buda-Pesth. Mr. Deri has stated in an article which I have seen in some paper, that they have established that fact by their experiments; but then it is to be remembered, of course, that they are interested in exploiting an alternating system, and it is their business to make the advantage appear if they can.

Mr. Mailloux:—If we can consider the filament of an incandescent lamp as an electrolyte, it would seem as though an alternating current would have less disintegrating effect; for it is well known that with an electrolyte subject to decomposition, an alternating current does not have any effect, where as with a continuous current it would have some tendency to exhibit migration of the ions in either direction. It would appear to me more rational to describe the deterioration of the incandescent lamp to a continuous current, and a *posteriori*, it would show that Dr. Moses's view of the filament of an electric lamp was correct.

Dr. Moses:—You may be interested in the following facts: When the first incandescent lamps were made they had been in existence from 50 to 100 hours. I do not think there was any one of them that had lasted more than 100 hours, and they commenced to go off. Well, Mr. Crookes—because these things traveled very rapidly by telegraph at that time—he advanced a theory—which is now known as "the Crookes effect," that there was a chemical decomposition that took place; first a combination of the residuum in the vacuum with a portion of the carbon, forming carbonic acid. In the latter part of the flame a dissociation took place; there carbonic acid was decomposed into carbonic oxide and free oxide. The oxygen came around and through some attraction of the glass, a static effect, the particles of carbon were drawn to the glass. That was his theory. If that were true incandescent lighting would be a failure. The first problem, then that Mr. Edison gave me when I went with him was to determine what that carbon was, on the inside of the globe, to analyze it and find out. Well it was only perhaps about a ten thousandth of an inch in thickness and the accumulation from a good many hundred lamps was required before we could even get a sufficient quantity to test. But I determined that in there was hydrogen, nitrogen, and some oxygen. That proved conclusively that the carbon had been bodily carried over; that it was a hydro carbon that was thrown off on the inner surface of the globe. That started him again about the perfection of the carbon which was the object he aimed at after that time more than the perfection of the vacuum, so as to get a carbon of very high melting point, in which he succeeded very well. Now there was another point which you asked about in connection with that—the carrying of the carbon, was it not—the migration of the ions. If you examine a shadow's direction, as the spectral shadows of the carbon on the glass after they burn for many hundred hours you will find that there is more of the carbon that is collected on both sides of that spectral shadow. The shadow is really the reverse of a shadow. It is a negative shadow. Now, if it was a migration direct, it would seem to me a current in passing around and carrying the particles with it, would throw them on the line of the plane passing the two poles instead of throwing them to the right and left. That is a phenomenon which is not explained by that theory. On the other hand, if the potential is too high and does not carry them around the curve with the carbon, it would tend to shoot them off in a general spray and the combination of those sprays, something like spray pictures where you put on an object at this distance would tend to leave the spectre of the negative on this side; so that it is practically to my mind a mechanical disintegration of the carbon.

Mr. Mailloux:—Why should it have that spectral shadow? It occurs to me that there is something to say in favor of the electrolyte theory. I have given attention to that phenomenon myself, and I never could reach any satisfactory opinion until Dr. Moses just mentioned the fact that it might be an electrolyte. From my past reasoning on the subject, this idea strikes me very forcibly and I think the presence of the spectral shadow would be explained by the fact that there would be analogously an electrolysis. Given, then, the fact that we have an evolution of the ions of some kind or other at each pole, then if they are free to move in all directions, it is very plain to see that they must go more or less in the way of each other, because it would be probably Crooke's phenomenon, or something analogous to that, by reason of which they have some momentum given to them which would project them into surrounding space; probably the ions are given off principally at the ends where the carbons are attached to their conductors. They would be projected in all directions from that, and the above particles which were projected could not reach the back of the carbon filament on the other side, and consequently they would throw a shadow. They might be diverted and sent off on each side of it. The very heat would, perhaps, serve to divert them and send them in another direction.

Mr. Rapieff:—A Frenchman, whose name I forget, once made certain experiments. He made a porcelain globe and put in a piece of carbon; he put the porcelain globe into another globe, all properly made, and exposed them to a white heat, about 2,000 to 2,200 Centigrade, for twenty-four hours. The result was that the first porcelain globe was penetrated by carbon, a heavy deposit of carbon formed on the top of it. After it was broken, the carbon was found to have passed through the pores and deposited on the second globe and outside surface of the first globe. It is conclusively proved that carbon has the power before the melting point to give forth vapors. If you run your lamps below the degree of incandescence, producing yellow or mellow light, then you have carbon not so high. But when you run your lamps or filaments recklessly, you bring it to a very bright incandescence, certainly it is above 2,000 Centigrade, then it might produce this effect.

Dr. Moses:—That proves very clearly that carbon will distill at different temperatures a different product. If you commence with the petroleum, you will get off products at 160, 180, or 200, and I should not be surprised if for every degree between there and 5,000 you would get off another product. In the ordinary air the difference between a vacuum of 50,000 and 1,000,000, would make on a 76 candle lamp, from 6 to 8 candles less of illumination; so that if you take a gas that is itself an excellent conductor, and that, as Mr. Grove himself says, comports itself very much like a metal, on account of its conductivity, why the loss is still greater.

Mr. Rapieff:—It is not only from the cooling effect of the hydrogen but also the conversion of the heat.

Mr. Mailloux:—I would like to ask here if the form of the cross section of the filament of an incandescent lamp has not a great deal to do with the illuminating power or the economy of the lamp. In other words, is not the ratio of candle power obtained to the energy consumed, influenced by the cross section of the filament.

Dr. Moses:—Certainly.

Mr. Mailloux:—Is it not a fact that a lamp filament having a circular cross section would give a better illuminating power than a flat one for a given amount of electrical energy? Now, there is an experiment that was made by Prof. Forbes and which I think is fundamental in this relation. He took a large conductor—one of the largest sizes of wire—and passed a current through it, gradually increasing the volume until the wire reached its limit of carrying capacity and became red hot. He now took the same conductor flattened, that is to say, a conductor of the same area of section but in the form of a very thin ribbon, and he found he was not able to redden it by any means of crowding the current at his disposition. This shows conclusively to my mind that what is good theory, namely, that a cylindrical filament has the most mass with the least radiating surface, must be good practice also, and that a filament which is stamped out of a sheet of paper or fibre cannot be as efficient as a filament which is made of circular section, such as thread, or out of round fibre, or else with a carbon covered wire, or anything like that. It is a subject I have thought on a great deal and I have studiously looked over the current literature to find somebody who had expressed an opinion about it, but I have found nothing and I thought I would bring it up this evening, so as to have it included with the disinterested discussion that has been brought out on the incandescent lamp.

The President:—The commercial lamps with cylindrical carbons seem in many instances to have given very high efficiency in the tests which have been reported, such as, for example the Woodhouse and Rawson lamp and the Stanley lamp. It may of course be nothing but coincidence, and I do not know that any exact experiments have ever been reported in relation to the form of a cross-section of filament, but I have observed that lamps with cylindrical filaments often show a very high efficiency. It would be very interesting, if somebody would take up that matter; it seems to be an important one. It is also possible that the lateral discharge which Mr. Rapieff has spoken of, between the terminals of the carbon within the lamp may be facilitated by the sharp corners of the rectangular filament. These would discharge in the form of a continuous electrical brush, if I may so term it. We all know that static electricity discharges itself with great facility, from a point or an edge, and that fact may play a part in the phenomenon.

Dr. Moses:—If you consider the vibration of a cylindrical rod, you would find you get much more uniform vibrations from that than from one of a rectangular section. The whole theory is that the carbon would vibrate more readily and uniformly, because it is from a cylindrical surface. That is theory; but in practice you will find one advantage with regard to the sharp angles of incandescent lights. The steel engraving is much more agreeable to the eye than a mezzotint, on account of the scintillations—the white and black. Don't you find that to be so?

Mr. Rapieff:—It is so, but they are from different causes. I want to tell you the advantage which Mr. Mailloux mentioned in the cylindrical compared with the flat. But the flat has one advantage, especially if bent as Mr. Edison has it. Under the heat, of course, the upper and lower particles are strained differently, and especially if you take the same section or area of the flat filament you would have in the round filament, the upper particles would be strained comparatively little.

Dr. Moses:—That is not the case, because the carbon having been put into the shape of a horse-shoe retains that shape.

Mr. Rapieff:—Still, the elasticity is there.

Dr. Moses:—But it shows that the internal and external strain exactly balance one another. Now as to the point I wanted to make, of the advantage of a rectangular section, I think the pleasure that we receive from looking at a steel engraving is the alternation of the white and black line. The particles of white are so small that there is no sudden break. Now, the incandescence of the angle of those sectional rectangles, is of course more than that of the side of the rectangle, and we get therefore in that rectangular shape a much more pleasant light to the eye. You may all have observed in those carbons made from carbonized thread a much more unpleasant light, although it is the same amount of light.

Mr. Rapieff:—You can attribute that to a different cause. Round filaments have smaller surfaces than other ones, and each unit of the row is brought to a higher condensation.

Dr. Moses:—If you look at that light intently for five or six seconds and then close your eye, you will see exactly what I mean.

Mr. Mailloux:—But in practice we are not called upon to look at the light. We want the light to look at us.

Dr. Moses:—But we have got to look at the light in order to find out whether these effects are so; to make full experiments we have to look at the light, or look at the effects of the light.

Mr. Mailloux:—If we look at it from its economical point of view, namely, quantum of light from a given amount of energy, and if it is shown that a cylindrical section gives a greater amount of light I do not think it matters what the scientific nature of the light may be, because we only use it to view objects by, and it is very much like an arc light in some respects. It is not a thing to look at, and whether it gives its light all from a little spot or from a larger surface does not matter especially, as "craquele" glass globes are generally used over them. We only want to get as much light out of it as possible and with as little expenditure of energy.

Dr. Moses:—If you take about a dozen strands of manila and carbonize them, so that their conductivity shall be the same as that lamp, and divide the current up, you will find that those small cross-sections have very much more incandescence than those larger sections, proving that, offering more resistance in proportion to the rest of the circuit, there is less current passing because it is on the same circuit, and yet you have more light.

Mr. Mailloux:—I believe that sustains the theory you advanced elsewhere sometime ago in regard to the improvement which you must expect in the economy of incandescent lamps from the smaller section of filament. I believe Dr. Moses was the first one to bring out that very important point; and although I was not present at the time, yet when I read the report it gave me a great deal of respect for Dr. Moses's opinions, and I felt very much more anxious to make his acquaintance, because I thought he was doing some solid thinking in the right direction; that after all that had been said in regard to the improvement of the incandescent lamp, there has been very little improvement in practice But looking at the sectional form of the conductor and reading what he had said, it occurred to me that Dr. Moses had there advanced one of the most important points in relation to the improvement of the incandescent lamp, and that in that direction the future growth should be looked for.

The President:—As the hour is late, I shall with regret be compelled to cut off this discussion which has been one of the most interesting I have ever listened to. I am sure we are all greatly indebted, not only to Dr. Moses, but to many other gentlemen present who have contributed valuable suggestions and information.

Mr. Mailloux:—I would like to put the fact on record at this our first meeting, that the new departure of The American Institute of Electrical Engineers, appears to be by far the most satisfactory we have had yet, not only in the number present but in the interest manifested in the discussion, and for my part I have learned more about one department of electricity—incandescent lighting—than I had learned elsewhere during the past year; and I hope this beginning is only a sign of a continuance in the same direction.

The President:—For my own part I have been very much impressed with the extremely practical character of the discussion. I have had the pleasure of attending a great many meetings of scientific societies in this country, and societies in our own line of work in Europe, and I certainly think that there is more to be learned from such a discussion as we have had here to-night, than from any that I have been fortunate enough to attend on the other side. The English electricans are very fond of discussing things in what I may call a theoretical or doctrinal way, and many who participate appear to be very careful to give as little practical information as possible as to what they are doing in the laboratory or workshop.

Mr. Mailloux:—I was about to say that in a previous meeting I broached the fact that in this country we were rather too practical; that we devoted so much time to practice that we had no time to give to theory at all, and I also expressed the fear of our being more a class of artisans than of scientists—to use words in their true application, that we were apt to be too much actuated by motives of self-interest. There is undoubtedly in this country a feeling which impels people to guard very jealously what they call their own trade secrets and I expressed the fear, that we might have to work hard to entirely eliminate that feeling and bring about in its stead a feeling of good fellowship which would induce people to come together, from every electrical sect, company, or art whatsoever, all knowing that they were meeting friends rather than rivals, and that they could give us their share of experience, their share of technical or practical knowledge, with the feeling that they were adding to the general sum of human knowledge and at the same time without fearing that their own particular trade, or their own particular "ism," would suffer from it; and I am very glad that this evening we have had a discussion which has drawn words from all who are interested in electricity, without reference to what I might call creed or faction,—from people interested in the same branch of electrical industry, I might say,—and yet who were to a certain extent separated from each other, not to say rivals in their business callings, and it shows that we have begun a good work in this our first meeting of this character, namely, bringing electrical men together and making them feel that they can do much to advance the progress of any art electrical in this country by putting their little mite of human knowledge into the big pile instead of keeping it in their own small heap. [Applause.]

Mr. Sidney F. Shelbourne was then granted the privilege of the floor for the purpose of adding to his paper read at the general meeting. His remarks appear as a supplement to vol. iii of the Institute transactions. The meeting then adjourned.

Special Meeting.

December 7th, 1886.

The special meeting for the consideration of the subject of Electric Street Cars was held at 130 Broadway, New York, at 8 P. M., December 7th, 1886. In the absence of the president, Captain Otho E. Michaelis, who was invited to take the chair, called the meeting to order. Mr. T. C. Martin read the following paper:

ELECTRIC STREET CARS.

The great question agitating street railway companies in this country at the present time is the use of some motive agency more economical and convenient than horses. It is no exaggeration to say that after about half a century of patient trial they have become profoundly dissatisfied with animal power and are ready to adopt any system that can establish its claim to their preference. Evidence of their feeling on the subject is seen in the fact that at the last convention of street railway men, the progress of electric motors was reported upon by a special committee whose optimistic statements were heard with pleasure. One of the most prominent members avowed that he regarded the promise of electricity as a motor with which to supersede horses, as very encouraging. Another said: "All honor to those who are giving an hour or a dollar to the development of this important agent." A third thought it the duty of the convention to extend an earnest and cordial greeting to every man who was "trying to replace bad with good." These sentiments should, I think, encourage us, who, with enthusiastic pride, have seen the rapid increase in efficiency of the electric motor, and who, no matter what may be our predilection for particular systems, assert and know that—as a bottom and basic principle from which to start—electricity is more than equal to all the demands that may be made upon it in the special service of propelling street cars.

The struggle for supremacy in this field of occupation may fairly be said to have narrowed itself down to three competitors —the horse, the cable, and the electric motor. Steam used directly is, it seems to me, viewed with more and more disfavor as the years go by, and has within city limits come to be considered very much in the light of a nuisance. The lowest cost of operation per steam motor per day, in usual service, that I have seen quoted authoritatively, is $8.50 to $9.00. But even if steam were cheap, there are grave objections on the score of noise, smell and dirt. The mere fact that steam locomotives have been in successful use fifty years, but are still denied employment on the streets, tells its own story as to public opinion. To some of us the banishment of steam from the tracks of elevated roads seems a matter of but a few years. As for gas, soda and compressed air motors, I am not aware that they offer any points of superiority over steam for the specific purpose under discussion.

Coming to horses, we find that in spite of their universal use and their faithful performance of duty, they inspire a discontent anything but complimentary, yet hardly to be wondered at. The statistics of horse-cars are important and interesting, and deserve our attention as covering the sphere within which the electric motor will operate. There are, according to the latest returns available for this year, about 625 street railways of all kinds in the United States and Canada. Taking of these 408 horse roads giving full and trustworthy figures, I find that they run 17,331 cars and employ 85,888 horses. If at the same ratio we took all the horse roads, upward of 500, we would arrive at a result of not far short of 25,000 cars and 120,000 horses, a total that probably comes near the actuality. Taking the other figures, which I have tested by three sources of information, it appears that all the horse-car lines are maintaining a proportion of at least five horses to each car. But that is inclusive, and making a reasonable allowance for the use of different cars for winter and summer, and for idle cars, as well as for "doubling-up" in heavy snows, a result is shown of at least eight to ten horses per car. This is the proportion usually cited, and it is brought out on a special examination of statistics for this city. Thus, the Broadway and Seventh avenue road has 121 cars and 1,350 horses, or not far short of 12 horses per car. The Central Park, North and East River road, with a total of 161 cars, has 1,223 horses, a broad average of 8 horses per car. The Eighth avenue road, with 112 cars, has 1,155 horses, or 10 per car. The Forty-second street and Grand street line has 50 cars and 485 horses, or 9 per car. The Sixth avenue line has 127 cars and 1,296 horses, or 10 per car. The New York and Harlem with 164 cars has 1,321 horses, or 9 per car. The Third avenue road, returning a total of 360 cars, has to keep up a force of nearly 2,200 horses. The large number of horses required is also to be learned from the fact, stated by Mr. Augustine W. Wright, that those on the North Chicago line, which is a favorable sample, work daily only two hours and seventeen minutes. Or to put it in another way, the 6,158 street car horses of Boston travel each about 10 miles a day only, or two hours' service.

The costliness of horses may be arrived at in yet other ways by the use of comparative figures. Mr. T. C. Robbins of Baltimore, a street car expert, gives the average cost of a horse-car per day at $6.50. I have had the same figures given me for Brooklyn and Philadelphia; while Mr. C. B. Holmes, of the Chicago Cable Railway, who has had great experience with horse service, says that the expense per car-mile by the cable system is 10 to 11 cents, as compared with 20 to 25 cents per mile when employing horses. On a daily run per car of 50 miles, that would be at least $12 per day with horse traction, and half as much for cable. Moreover, there are the great extent of valuable land required for huge stables and the heavy depreciation of stock. Few occupations are more exhausting to horses than street car traction, and the average railroad life of a horse is but from three to five years. In other words, out of 100,000 horses, at least 20,000 every year die, or become useless for their work, and drag out the remainder of their existence in other occupations. "How are you getting along with those old horses I sold you," said the street railway president to Mr. Sexton, the undertaker. "Pretty well," was the reply. "I tried 'em first in the mourning coaches, but they were too slow for the ladies. Then I put 'em in the hearses, and I haven't heard any complaints from that quarter."

The cable has already made its way into use on a large number of street railways doing a heavy business, and is, it must frankly be admitted, a vast improvement on old methods. It has enabled those roads to handle a traffic that was utterly beyond their capacity before. It has accelerated speed, has lessened accidents, has given the streets a cleaner look, has, it would seem, cut down expense, and has certainly raised the value of property wherever put in. But I doubt seriously whether in view of the enormous first cost of the cable system and the excessive waste of power, it will make very rapid strides, especially when subjected to the rivalry of electric motors. At the recent street car convention, the new cable roads at Kansas City were presented for favorable notice, and as they were evidently considered good specimens, let us accept the figures. The Metropolitan road will cost $50,000 per mile of single track, and I observe that it is claimed with regard to the Philadelphia system that the track there could now be duplicated at about the same cost. The Kansas City cable company gives some interesting results of a test of its engines and machinery, from which I gather that with a total of 159.7 h. p., no less than 119.06 h. p. was required for the cable machinery, leaving only 40.64 h. p. for cars and passengers. In other words, just 25 per cent. was available for actual traffic. This waste will strike electricans familiar with the high efficiency of dynamos and their transmission of power as extraordinary. But it is confirmed by a statement from Mr. C. B. Holmes of Chicago, who says that his cable railway required for ordinary operation, engines of 477 h. p.; that it took 389 h. p. to move the cable and machinery, and that 88 h. p., or only 18½ per cent. was used for the propulsion of the cars at nine miles an hour. Mr. W. W. Hanscom, in a careful review of the conditions applying to the cable lines of San Francisco, gives a total daily average percentage on the seven roads of 68 per cent. of power for moving the cable, and 32 per cent for the cars and passengers. Two miles of new double track in San Francisco, fully equipped, have just cost $400,000.

I do not know that these figures call for comment, as those presented later on in regard to electricity will serve for purposes of comparison. But they may be supplemented by one or two observations. It is evident that there is an objectionable rigidity in the cable system and that it has narrow limits of applicability. A cable road, of whatever kind, needs a very large patronage. Mr. P. A. B. Widener, well known in connection with Philadelphia street railways, said last year: "To maintain a cable road you must have a certain amount of business in order to be self-supporting. It costs as much to run the cable for half a dozen cars as for half a hundred. Small roads, or feeders to the main line, are run more cheaply by horses." It will be remembered that great trouble was experienced in Philadelphia in rendering the cable system there operative last year. The assertion is made by those who should know that 12 miles, costing between $40,000 and $50,000 a mile, required $250,000 in repairs and renovation inside the twelve months; but, as the *Ledger* put it philosophically at the time of the breakdowns: "It is claimed that the delays and other annoyances that have been experienced by the company have been slight in comparison with those met with in Chicago when the cable road there was in its infancy." We New Yorkers and Brooklynites are more familiar with the mishaps on the East River Bridge, and from the arguments made here and elsewhere against cable roads we have learned that the cables wear out quickly, besides being ceaselessly noisy and requiring a conduit that must have such a depth as to become an unhealthy drain or sewer.

We reach now, in the due course of our survey, the use of electricity as compared with horses or cables. You will, I believe, bear me out when I say that the confidence of electricians in the ability of electrical means to propel street cars is as strong as it could possibly be, and is, moreover, based on no small amount of work and experience. I might affirm that the general introduction of electric motors is now largely a question of coal bills. I might affirm that it has more and more resolved itself into a question of mechanics; aud in both statements I should have your concurrence. I may broadly state that in Europe, where a large number of electric roads exist already, they are paying well and multiplying; and that such roads in this country had, some months ago, carried altogether over a million passengers, or a daily traffic of 3,000 passengers for a full running year, without any recorded injury to a single patron, while several new roads have of late gone into successful operation. But at the risk of covering much ground with which you are familiar I shall venture to give an outline of some of the methods by which electricity is applied to street-car service, as well as some of the data establishing its claim to superiority. I do not know of any point on which a fair comparison need be shirked; I do not know of any difficulty that can balk the infinite variety of our electric art, and as this society has never hitherto had the subject before it, I am encouraged to go a little into detail.

We have, in using electricity for street cars, the option of so many methods that the very flexibility of the application becomes a recommendation. We shall, perhaps, best spend our time in considering three or four of the leading methods, with incidental reference to the peculiarities of individual cases in each. I propose to take the third-rail system, the overhead system, the conduit system and the storage system, and, without any intention of invidious discrimination, to pick out, for the exemplification of each, some of the roads and cars that have been running or can be seen and tested.

Let us begin with the third-rail system. The Daft road at Baltimore, now in its second year, has been so often described that full details here are not necessary, but it furnishes some interesting figures. The cost of electric power there against horse-power at $6.50 per car has been $4.00 per car per day, with an increase for the year of 83,986 passengers. Mr. T. C. Robbins reported as follows to the street car convention: "It was started on a purely commercial basis, as a purely commercial transaction, and has continued, and is now being extended, simply because it has proved its right to stay by the performance, which leaves little to be desired." The largest item in the expenses at Baltimore is coal at $3.50 a ton. Another third-rail road, the Highland at Detroit, on which there are none of the grades and curves that rendered the Baltimore road expensive as to fuel, is in very successful operation. Like the Baltimore road, it has a wheel for making contact, but, unlike it, has the third rail neatly sunken between planks. It runs out of the city for three miles. The car in use is the same as those on Broadway, this city. Mr. Frank Fisher, whose motor is used, informs me that on a recent Sunday on a thirteen hour schedule, the road carried 5,500 passengers. The coal consumption was a little over 400 lbs. The coal—screenings—costs $1.25 a ton. The success has been so great as to lead to a development of matured plans for the increase of the service there and on a new local road to be begun in the spring.

You will agree with me, I think, that third-rail systems must be limited to a low electromotive force, and to suburban or rural districts. Even there they have a large opportunity.

Coming to the overhead conductor systems, the Van Depoele roads form an important group. These roads are now in operation at Detroit, Port Huron, Mich.; Windsor, Can.; Appleton, Wis.; Montgomery, Ala.; and Scranton, Pa. Mr. Van Depoele suspends his feeding conductor by side poles, or, as at Appleton, has double wires, corresponding to the track, but immediately above it at a height of 18 or 20 feet. The little Windsor road, two miles long, with two cars, started in June, 1885, has paid for itself. I may mention that when I went on it last August, one evening, I visited the generating station. It was deserted and in black darkness. I made the trip and then went back to the station. The darkness was blacker, and there still was no sign of attendance, but the 30 or 40 passengers each turn were none the wiser and none the worse. I don't approve such practice, however. The Appleton road, with five cars, is the first in this country run by water power, depending, and with great success, upon a pair of turbines that will develop 100 h. p., and are now driving a 60 h. p. dynamo. The Montgomery road is notable as being a complete city system, including ten miles of track. The Scranton road that started last week has two features of special interest. One is that in a city of about 50,000 or 60,000 inhabitants the use of the overhead conductor is allowed. Another is that the line is operated from the electric light station. The road is 2½ miles long, with 12 grades, mostly over 6 per cent. There are already in use two heavy Pullman cars, running at a speed of from 4 to 15 miles an hour. The current is conveyed by a conductor $\frac{3}{16}$ of an inch in diameter, the rails forming the return. A traveler with rollers and a flexible cable passes the current to the motor, which, it is worthy of notice, stands upon the front platform in sight of the driver. The electric light station is well satisfied with only $9 a day for running the 60 h. p. generator, and it is evident, therefore, that an increase of rolling stock will involve very little increase in cost of power. Here is a hint by which electric light men nearly everywhere might profit.

In the overhead conductor category should be included Mr. Daft's new roads at Los Angeles, Cal., one 3½ miles long and the other 2½ miles. A peculiarity is the placing of the motor in the centre of the car, occupying the room of but two passengers, and leaving both platforms clear.

The overhead bare conductor systems are also restricted to currents of low electromotive force. But they, as well as the third-rail systems, do work it is impossible to perform remuneratively by cable, and which would often be beyond the range of horse or mule power on either philanthropic or business principles. Provided permission is obtainable for running the wires, the overhead conductor system seems cheapest, if not best, for cities up to at least 50,000 population. I believe a double overhead conductor system well built should cost from $1,500 to $2,000 per mile. The single conductor is, of course, much cheaper.

There are in the United States about 40 cities with population above 50,000. In almost every one of these it would be necessary to resort to the electric conduit system, third on our list, unless the storage system be tried, or a combination of the two. At the present time, the outlook for electric railways with conduited mains is very favorable.

The first exemplification of a conduit system in this country was given by the Bentley-Knight Electric Railway Company in 1885, at Cleveland. A working section of their line can now be seen at the Rhode Island Locomotive Works, and as it illustrates in a striking manner the principles involved, I will touch on a few of the leading points, now described for the first time. The conduit is made to resist the heaviest wear and strain of street traffic. The surface opening, or slot, is only ⅝ of an inch wide, and the total width of metal at the street surface is but 3 inches. The conduit is kept clean by a broom of peculiar shape suspended from the car. This broom is said to have swept out in a single trip the accumulation from 12 hours constant snowing. At convenient points catch-pans with sewer connections receive the sweepings and effect drainage. The two main conductors consist of channel iron connected by expansion joints and lined with a continuous strip of copper of sufficient size to carry the current with but small loss of energy. These conductors are fastened to the side walls of the conduit on insulators of vulcanized wood dipped in white lead. The insulators are strongly set in sockets in the cast-iron supporting yokes. Neither the traffic rails nor the conduit structure form any part of the electrical circuit. To provide for switching, a movable tongue is pivoted at the point of branching, so as to rest on the top of the conduit and to be readily set to close either of the branch slots and direct the contact plow into the other. A corresponding conductor tongue within the conduit is moved at the same time. The contact plow for making connection consists of a flat frame hung from the car by transverse guides, on which it is free to slide the whole width of the car and extending thence down through the slot of the conduit. It is provided with a swivel joint, so as to adjust itself to all inequalities of road or conduit. This frame carries two flat steel insulated conductor cores, to the lower ends of which are attached by a spring hinge small contact shoes of chilled cast iron that slide along in contact with the two main conductors. At the upper ends are flexible connections leading to the motor. This plow can be inserted or withdrawn through the slot at will, the spring hinge allowing the contact shoes to straighten out into line with the conductor cores when the plow is pulled upward and the shoes strike the insulating lining with which the slot irons are provided. By no accident, therefore, can anything be left behind in the conduit to obstruct succeeding cars. The plow guides are hung on transverse axes, and are held in a vertical position by a spring catch that gives way when the plow meets an irresistible obstruction, and hence the plow is automatically thrown completely out of the conduit without injury, being also immediately replaceable. The contact shoes will stand weeks of wear, and cost next to nothing. The frame of the plow has wearing guards of hardened steel wherever it can touch the edge of the conduit slot, and these are also readily renewed. Two plows are used on each contact for the sake of absolute reliability, and to prevent flashing at the contact. The connection between the wheels and motor consists of a system of gear wheels and connecting rods, the gears being deadened so as to be quite noiseless. The company makes a completely equipped steel frame truck, with motor, etc., upon which can be placed any car body. These have a wheel base of 6 feet, a standard gauge of 4 feet 8½ inches, and can be used on curves with a radius of 45 feet. A motor of the Gramme type is used under the car. For long distances the motors are in series, with current constant; for short distances, the motors are put in multiple arc, and a new form of resistance is used.

Such are the main features of the system. Of its eminent practicability there should be no doubt. The question again is one of expense, and I therefore give transcripts furnished me by Mr. R. W. Blackwell, of actual estimates submitted quite recently and now under consideration. The first is for the equipment of existing street railways in the city of New York, 3 miles, 1,440 feet, double track, minimum headway 1½ minutes, average speed 7 miles per hour, running 24 hours per day, very heavy traffic, maximum grade 3 in 100.

CONSTRUCTION AND EQUIPMENT.

Conduit and conductors, 34,560 feet, at $3, $103,680; motor trucks, 37 at $1,200, $44,400; 50 h. p. dynamos, 12 at $2,500, $30,000; steam power plant complete, $27,750; foundation, $5,000; engineering, $3,000—$213,830.

ANNUAL EXPENSE.

Coal, 14 tons per day, at $3, $15,330; engineer and assistant, at $2.50 and $2 per day, $1,642.50; firemen, 3 at $1.50 per day, $1,642.50; machinists, 2 at $2 per day, $1,460; total running expenses, $20,075. To which should be added interest on construction cost ($213,830) at 6 per cent., $12,829.80; and also depreciation of plant at 3 per cent., $6,414.90; total expense and charges, $39,319.70.

The second is for a down-town cross-town road in the city of New York, greatest grade 1 in 12, double track: 12,660 feet conduit (extra heavy), at $4, $50,640; 20 motor trucks complete, at $1,200, $24,000; six 50 h. p. dynamos, at $2,500, $15,000; steam plant complete, $20,000; foundation, $2,000; engineering, $2,500—$114,140.

Of course, I do not present these figures as those upon which all authorities are agreed, but they have their value as being bids on actual work.

The conduit system of Mr. W. M. Schlesinger, in use for four months past by the Union Electric Company at Philadelphia, with a car running 9½ miles an hour, has noticeable peculiarities. It consists practically of two conduits, the upper of heavy channel iron for connection, the lower of wood or cement for drainage. To insulate the conductors, an angle iron is riveted to the top flange of the channel iron in such a manner that one of its flanges, pointing downward parallel to the main side of the channel iron, forms one side of the slot. In the inverted trough thus formed, the copper bar conductors are fastened, the contact being on the under side. Against the conductors, pulling upward, rub or press springs, making a firm, close contact under control by means of a frame holding the springs. In Mr. Schlesinger's system, the motor is under the car between the axles, and geared to them by means of chains. The motors are intended to work in multiple arc.

There are other conduit systems, among which I might mention the Van Depoele used at Toronto, I believe, in 1884, at the exposition. But my object is not so much to describe all the systems as to bring up main features and relative costs. I will, therefore, pass on to point out that whereas in the cable system, with its costly conduits, the available power for the cars and passengers reached only about 25 per cent., in the electric conduit system, requiring for generators, conduit and conductors, etc., but half the outlay necessary on a cable system, the net return of power, as you are well aware, reaches at the minimum from 50 to 60 per cent. Mr. G. W. Mansfield, who has had considerable experience with the Daft company, puts it as being at least 56 per cent. I note, too, that with the use of the Holroyd Smith conduit system, the Blackpool road, England, has reported earnings of $1,735 in a week, with a total expense account of $225, running 2,760 miles, and carrying 44,306 passengers.

A distinguishing feature of the conduit system is that it is the only one with which high potentials can be employed on the streets. With it, also, the power stations can be placed near ample water supply or where rents are low, or can each be given a section of road to operate.

I approach the next and last system on our list, that of storage, with some degree of nervousness. In more than one quarter, the man who comes out with a kind word for the secondary battery is set down as either a knave or a fool. I cannot see why he should be regarded as either, although he may perhaps be more than ordinary sanguine and hopeful. I have myself ridden very comfortably in a street car propelled by storage batteries, so that I know the thing can be done, and I understand that storage is to be extensively used at an early date by the North Metropolitan Tramway Company in London. At Antwerp, in 1885, after six months' competition with four other cars using either steam or compressed air, the Julien electric storage car took the first prize, awarded by a jury of well-known experts. There were in all twenty-three points of comparison. The Julien car has since been tried in Hamburg, and another has been in operation on the Eighth avenue line in this city. Mr. Widener, of the Philadelphia cable line, has traveled on it and is to try it, being very favorably impressed. But, as he remarked publicly, "The question is as to the cost of maintenance of the cars and the furnishing of motive power." It will be admitted that there are advantages in having each car an independent unit, offsetting the disadvantage of carrying the dead weight of batteries; and that single cars on any road can be taken in hand for change, so that existing rolling stock can be progressively adapted to the new conditions. This involves a smaller initial outlay and gives opportunity to train the present force in its unfamiliar though simple duties. Now, regarding first cost—I have never seen any figures as to the expense of an equipment of a car here with storage batteries. It has been said that two sets for an ordinary street car would cost about $1,500. That seems high. The Julien company states that the cost of the horses for a car more than covers the initial outlay of the change, and I believe the firm estimate is also made by the company of a total daily running expense of not to exceed $5 per car in cities on heavy traffic. As to life of the batteries, those in the Hamburg and Julien car have now been in daily use since April, and they show by test a return of more than 80 per cent. of the power with which they are charged. The car is running on regular daily service. In respect to American storage batteries, it may be mentioned that the Electrical Accumulator Company, whose officers have a standing in electrical circles, guarantees two years' life for its new battery and an 80 per cent. return of power. The criticism has been made that ordinarily 20 per cent. of the stored energy is retained on each emission, but obviously that is no loss, forming simply 20 per cent. of the succeeding charge.

Putting it broadly, the storage system, in spite of its various conversions of energy, has a superiority of at least 25 per cent. over cables. Some of you will put it far higher, but as I have said, in the absence of the data of prolonged work, I prefer to put it low.

I think we shall see a number of efforts shortly made in the direction of using secondary batteries for regular work on street cars, and the results will merit our most careful study. There are, moreover, some ingenious propositions for combining the conduit and storage systems, so as to enjoy the benefits of both. Mr. J. M. Pendleton has described a plan of his of this nature, and Mr. Elias E. Ries, of Baltimore, has also carefully elaborated such a system, in which storage plays an important part.

Here, then, illustrated in a variety of ways and by numerous examples, we have a comparison of electricity with other power for propelling street cars, and an idea is given, very imperfectly, of the wide range of choice that electricity itself offers as to methods and means. Much of what has been said has its direct and favorable bearing on elevated railway traction, as well as on that for underground railways, but the time will not permit me to pursue the subject any further. Many points of discussion arise as to the connection of the car axles with the motor; the use of independent motor cars or of motors on the passenger cars;

the types of motors and of conduits or conductors; the potential that is safe under certain conditions; the methods of regulating motor speed; the use of resistances; but all these and others I may leave to you, many of whom are doing practical and creditable work in this field, and who by thus "hitching your wagon to a star," have shown that street cars, if run by electricity, may yet be brought up to the most advanced notions of humanity, comfort, convenience and economy.

All that remains is to press onward and occupy the pre-empted territory that awaits us. As Emerson says: "Our duty is plainly not to throw ourselves across the track, not to block improvement, not to sit still till we are stone; but to watch the uprise of successive mornings and to conspire with the new works of new days." This sentiment may surely be appropriated by modern electricians, who every year put their skill to some severer test, and every year win fresh triumphs. In beginning this street railway work, we may count on a large and profitable travel for some time to come, through the mere novelty of the thing, but as the art improves it will more and more manifest its right to street railway propulsion on the strictest business principles, as well as on every other ground of merit.

DISCUSSION.

The Chairman:—Gentlemen, I am sure that we have all listened with great pleasure and profit to Mr. Martin's exceedingly interesting, simple and lucid paper, and I now declare the subject open to discussion. In this connection I desire to say that under the rules of the Institute our guests here this evening, who are not members, are invited to take part; and I beg to assure them that we shall be very happy to listen to any remarks they may desire to make.

Mr. John Murray Mitchell:—Although I came in nearly at the close of the reading of this paper, I have been extremely interested, and have listened with great attention to everything said by Mr. Martin, and have arisen only for the purpose of corroborating what he has said in regard to the Baltimore road, and also to direct your attention, and I think perhaps also his, to the fact that in the comparison shown in his report between horse power and electricity, that the ratio given of $6.50 to $4.00 is not so advantageous to electricity as it should be, because the average speed which is accomplished there with electricity is eight miles an hour and the speed formerly attained was only four miles an hour, which of course reduces the cost in comparison—so that the cost of electricity should be put at about $2.00 as against $6.50 instead of $4.00 as against $6.50. That I know has not been brought out by Mr. Martin's report directly, but I think it worthy of attention.

I should also like to state that as counsel for the Safety Electric Railway and Power Company, which operates under the Daft patents, I had the pleasure some two months ago of closing a contract in Pittsburgh for the equipment there of a railroad to be two and a half miles in length, where the grade is 14 per cent. going up one of those terrible Pittsburgh hills. We first thought of equipping it without any safety device and relying on the mere traction attained by electricity and the weight of the motor; but as there happened to be a curve with a fifty foot radius on the grade of some seven hundred feet to the mile at that point, and as this happened to be on an elevated structure, something like our elevated roads, and as the danger, if there should be a slip of any kind in going around that curve, would be very great and would result probably in great loss of life, we thought it better to adopt a system which Mr. Daft himself examined and approved of, using a species of cog rail, but doing away with the old form of cog. It answers the same purpose without having the disadvantage and expense of the old system. That road I think will be fully equipped and probably be running in the early part of next summer. We have there the underground conduit, which is being constructed by Mr. Wharton, of Philadelphia. He took the sub-contract. He is a man who has built a great many of the cable roads. We have a very strong form of conduit, it being formed of slot rails, seven inches in height and they are supported by ties and also by chairs which are made very heavy and almost strong enough to firmly hold the slot rails without any other support. This road also has the overhead system, making a combination of the two which has not been previously tried in this country; and I hope that at the time that that road does run I may have the good fortune to see a great many of you, gentlemen there, and have the pleasure of taking you out on the first ride.

MR. WETZLER:—Mr. Martin has remarked in his paper that one of the principal points to be considered was the coal bill. It is interesting, therefore, to note that in the case of the Julien

Electric Railway at Hamburg, a calculation has recently been made on the basis of sixteen hundred kilometers run. equivalent to about one thousand miles. Mr. Huber, the engineer there, calculates that for the thousand miles run, the energy required to propel the car one kilometer is three-fourths of a horse-power per hour, on the average. Now, that figures out in this way. Assuming that three pounds of coal per horse-power per hour is what a fair average engine will do, the energy of coal required to propel the car one mile would be three and a half pounds of coal per car mile. Now, take, for instance, the Third Avenue road in New York. On a basis of three and a half pounds of coal required to propel a car a mile, we should have, assuming there were three hundred cars—I think Mr. Martin puts it at three hundred and sixty—that would give one hundred and seventy-five pounds of coal per car per day. I am basing that on a run of fifty miles per car per day. That would give 52,500 pounds of coal a day, or twenty-six and a quarter tons. Calculating a ton at three dollars, we should have for the coal bill alone per day, only $78.75—and that is with accumulators. I think the company would be very willing to spend $78 for coal, if that will do it. That is what it figures out at.

The Chairman:—We have a press of various gentlemen, not only well known but distinguished in connection with this branch of the subject that we are studying, and I am going to take the liberty of calling upon some of them. First, I will call upon a distinguished foreign gentleman who is with us, whose name has been specially mentioned as familiar to us all, Mr. Julien, assuring him that we shall all be delighted to hear him speak on the subject. One of our members present will be very glad indeed to translate what he has to say, in case he will favor us. (Applause.)

Mr. Mailloux translates to Mr. Julien the remarks of the Chairman.

Mr. Julien addressed the meeting in French.

Mr. Mailloux translates:

Mr. Julien expresses his thanks and his extreme gratitude for the honor conferred upon him, and wishes to say that as Mr. Martin has entirely covered the points in his paper, it is scarcely necessary for him to elaborate them further, and that he could only speak of personal matters if he were to attempt to discuss the subject; which he thought might perhaps not seem acceptable.

Upon my assuring him that such would not be the case, he consented to go on and give us some details.

One point that I interrupted him for, because I do not wish to forget it, was the fact that he brought out so clearly—although I dare say not many of you understood it—that the circumstances, under which the tests were made in Antwerp, were such as to represent almost an inimical attitude to the question of electrical traction by any process whatever. He said that during the six months that the tests lasted, every detail of the system was subjected to the closest scrutiny; that the cells were sealed and that they were almost kept under lock and key; that he was scarcely allowed himself to look at them. The tests were made by judges, the most competent engineers and electricians, and they were made with every precaution that might be necessary to prevent any tampering with the regular order of procedure, and, as he facetiously remarked at that time, there was a feeling which was quite current in general engineering circles that there was not much reliance to be placed upon electrical traction, particularly by accumulators, and also by electricians—that even electricians themselves were in such an infantile state of evolution that it might be well enough to wait until they had grown a little more, and as to accumulators, that it would be well enough not to think of them for some time.

Mr. Julien continued in French.

Mr. Mailloux continued translating:—

Mr. Julien remarks referring to the statement made by Mr. Martin, and the assertion made by Mr. Wetzler, that the cost of energy necessary for electrical traction is three-fourth of a horse-power per kilometer, and that as the energy required for the lamps must also be counted in, which he thinks would certainly be 10 cents a day, the total expense of about three dollars would be necessary for the energy actually needed, and counting an expense of two additional dollars for all other costs of maintenance, wear and tear and interest, and various other expenditures, that we would arrive at the cost of five dollars, which has been mentioned by Mr. Martin. Mr. Julien said that the cost was thus found by the experiments made at Antwerp, and that this cost might be considered, so to speak, historical; that it might be conceded to be the cost on which we could safely calculate the probable expenditure of running the electrical car.

Mr. Julien mentions a very interesting case of his desire to submit his system of electrical traction to the electricians of Paris, and to a committee, and to exhibit it there and let it be tested in order that the figures and statements as to its value might be corroborated and that also the facts as they have been found at Antwerp might be known more generally. He states that there also he found a great deal of opposition; that the French electricians had been almost systematically preaching against and slandering the accumulator. (I might remark incidentally that perhaps they had had too much of Mr. Phillippart in times past. That may have had something to do with their disgust.) At any rate a jury comprising some of the most able electricians was selected. Mr. Julien's endeavor was to place himself under exactly identical conditions with the system of electrical traction which was exhibited by the firm of Siemens at the electrical exhibition of 1881, and to make a comparison with that on the score of cost, facility of running and various other conditions; and that although the jury comprised men of conservative inclination and disposition like Fontaine, Hospitalier and others, men very well known themselves in connection with the application of electric motors, and although M. Fontaine himself took charge of the accumulators and discharged them himself and did not let Mr. Julien have anything to do with the manipulation, he said that he had received a dispatch this very morning, stating that they had conceded every point that he had made with them, and that they had found the figures as to cost, which he had given them as being the figures representing the cost at Antwerp, had not even been reached; that the actual estimate of cost of running under the conditions at Paris was much more favorable than those arrived at in Antwerp. (Applause.)

I must not forget to mention the most important thing, namely, that he has received two diplomas of honor, one for the car and one for the method of accumulators.

In reply to a further question which I asked Mr. Julien at the end—but I had so much to remember that I forgot that—he said that the experiment had been going on since last July with two cars; there were two cars in continual operation, so that the test could be made very thoroughly and the expense arrived at very correctly.

MR. JULIEN continued further in French, and Mr. Mailloux translated as follows:—

Well, gentlemen, I have managed to get along so far pretty well; but I doubt very much, as good a friend as I am of the English language—I speak it pretty well—it is my native language, and as much as I think of the good old Saxon, I doubt if it is adequate to express the very eloquent and beautiful peroration Mr. Julien has just given us; but I will make a feeble attempt. It is nothing more nor less than *spirituel*, extremely well conceived, brief and to the point. His idea is briefly that he does not wish to occupy your time any longer by talking himself. He does not think it is well for people to say too much of themselves. He thinks he has already taxed your patience, but he merely wishes to add that he would be happy to demonstrate here in America the facts and theory, and the system which he is interested in, to the satisfaction of all those here present, and that he will consider himself happy, if, in coming among electricians of an intelligence as developed, and of a genius for invention as skilled and as well known as that of America, he has succeeded in contributing one stone to the great edifice of Science, particularly that of the application to the subject of electrical traction. (Applause.)

THE CHAIRMAN stated that he saw present a gentleman well known to all in connection with the subject, whom he desired to call upon—Mr. Van Depoele. (Applause.)

MR. VAN DEPOELE:—Gentlemen, I think you know nearly as much about it as I do. Everything has been stated this evening, and I can simply corroborate what has been said. Still there is one little plant that I might give the exact cost of, because the cost is about the main thing in the whole business here. We ran a plant in Minneapolis, Minnesota. This is, I believe, the most extensive electric railroad ever run in this country or anywhere else so far as I know. We had there about a sixty horse-power motor, and the train consisted very often of over ninety tons weight. We have run it for almost nine months. (I might state also that they have tried a soda motor there, which I will speak of later.) But at all events, we have been running there at an expense of about three thousand pounds of coal a day—that is, starting up at six o'clock and running till half past eleven at night—and certainly any of the locomotives that used to do the work before, consumed as much as four tons of coal a day for the same work, which shows that although we have to transform our power twice, that we will still effect a great economy over the ordinary steam engine. Our system is not now running there for the simple reason that some other parties persuaded the authorities there that they were going to bring them something wonderful to use in the shape of a soda motor (a soda fountain with a stick in it, or something of that kind). The soda motors came and we went off the track and let them on. But let me say, those soda motors can hardly pull themselves, and at present are lying there like a lot of old scrap iron in the shops of the railroad. Of course, the authorities there would not at the present time like to take back the electric motors for fear of stultifying themselves. But we ran very satisfactorily over that route, using only very crude apparatus. The whole thing was only a common freight car with four ordinary thirty-six inch wheels and an ordinary gearing from the motor to the countershaft and from the countershaft to the axle of the wheels of the common car. During that time we wore out only one belt and operated the road eighteen hours a day, hauling forty-seven of their regular railroad trains. So it was shown that electricity can be used for heavy work as well as for light work.

Another instance where we might give figures—of course all this figuring will come easier after we have big plants running—is this: We are now putting up a large plant at Montgomery, Alabama, where we will have twelve cars running; but so far as we have tried it— and the grades are six and a half and eight per cent. there; in fact there is not a foot of level ground in Montgomery—with two cars we have consumed an average of nineteen hundred pounds of coal a day, so that it costs about five and a half or six dollars a day with the two cars including the engineers' wages. That is a very small plant, and if small plants can do as well as that, the larger plant can do much better. (Applause.)

Mr. Julien made some further remarks in French, which were translated by **Mr. Mailloux** as follows:—

Mr. Julien wishes the privilege of speaking to say that he was ignorant of the fact that a fellow countryman of his, M. Van Depoele, was among us, because he would have felt it incumbent upon him to begin by paying tribute to the labors of an electrical engineer whose work he admires greatly. (Applause.)

Mr. Mailloux:—Mr. Chairman, I am interested in electric railway matters just as I am in other branches of electrical engineering, such as occasionally come under the province of an expert to be investigated. At the same time while I am watching its development I like to look at the subject from a practical point of view. There is a question which is now agitating the minds of practical engineers and which gives me the opportunity to ask Mr. Van Depoele a question. It is this: There is a great deal of doubt, a great deal of difference of opinion, as to the manner in which the energy shall be applied to the shaft of the driving wheels. I heard Mr Van Depoele say that he gears his motor to a counter-shaft, and that he conveys the motive power from that countershaft to the driving wheel by means of a link belt. Now that link belt is as I understand some to say, a bugbear of the electric railway, or one of them, and I would like to ask Mr. Van Depoele about the length of time that that link belt has been running; also about how much velocity it will endure with safety; that is to say, how many feet per minute will it run without making too much noise or without being strained unduly and also how long the link belt will last under those conditions?

MR. VAN DEPOELE:—I will be very glad to answer this question, gentlemen. We have some link belts running now which have been used for the last eight or nine months on street cars. We have tried several different modes of transmission—to gear directly to the axle of the car by a means which will alleviate the vibrations transmitted by the axles running directly over the road. There at once we have a flexible connection between the motor and the car in the shape of a link belt. The motor can stand on the body of the car itself, and consequently does not participate in the heavy vibration to which it would be subjected if it were carried directly by the axles of the wheels. Consequently with street cars that is about the best connection I can find at present. I would like to be understood that any ordinary belting in the market would not answer the purpose. We have a link belt which we had made for this special use. We have tried the cast iron belt and found that to make considerable noise, wearing out too fast, and incapable of running at a high speed. I have run at thirty miles an hour. I did not formerly believe myself that a link belt could do the work, but it seems when it is solid and correctly made you can run it at that speed without hurting it. The link belt used by us consists of two side pieces of steel pressed into shape and the steel side pieces are then fastened to a steel thimble at the upper end. Right through that steel thimble goes a pin, the pin catches the two lower ends of the next link and consequently there was no friction in the small parts but the friction is borne by the larger surface of the thimble. Right over the thimble is a steel roller. There is really no wear to the chain. We have had in Windsor, Canada, a chain running for about eight months, and in fact it is just as good to-day as when first put on. Of course for running fast we have to use another method.

Mr. Mailloux:—Was the belt running at that rate.

Mr. Van Depoele:—The belt was running then I should judge at a rate about one-third less than the wheels.

Mr. Mailloux:—Twenty miles an hour?

Mr. Van Depoele:—Fully twenty miles an hour; and at the end of the track I stopped to feel whether the belt was hot, and it was not even warm. Of course for heavy work and fast speed I think the link belt would not be suitable. Then you should have a direct mode of connecting. Certainly it is very difficult to get a good connection between the motor and the axles of the wheels, because to make a motor large enough to connect directly with the axles of the wheels without gearing, would require the motor to be too large. I think it would be out of the question to make it in that way for ordinary speeds and bring it within reasonable limits. But to gear back of course you would have to use some kind of gearing. Friction gear I do not take much stock in. It is not reliable; it wears out and there is always some trouble about it. Of course the cog gear is positive, but it makes too much noise. But if you put up gear that is solid and mathematically true and with good lubrication, I find there is not much noise when the gear is entirely covered up the same as we have in Scranton, which is noiseless. It is thoroughly boxed and works well and does not seem to wear, and fits tightly; although how long it will last of course we do not know. We have several sets running and they work well. If you gear back at one to eight, you will have a good deal of noise; one to four you will have scarcely any noise; one to eight there will be serious wear; one to ten of course worse. There is a medium between these proportions, and you will have to take your choice in making your plans; but the link belt I believe is the best thing for the street cars to-day, that is, a belt made specially for the purpose.

Mr. Mansfield:—Mr. President and gentlemen, I think that one of my years should abide by the old saying that my father always used to hurl at my innocent head whenever I attempted to say anything, and that is, that "little boys should be seen and not heard;" and that is the way I feel here. There are so many older heads and so many more experienced heads in regard to the mechanical and electrical problems, that I feel incompetent to say anything which would be beneficial or instructive. But I will certainly support Mr. Van Depoele's remark that it is a most difficult and exceedingly troublesome thing to find any good method of connection between the motor and the driving wheels. He has spoken of a variety of methods of doing it, and there are other varieties yet of which he has not spoken. But referring to his remark that the link belt gives a flexible connection between the motor and the driving shaft—that is an excellent plan and would be necessary where a flexible connection is needed. I would like, however, to bring up just this one point, that we have before us two distinct fields to labor in. One field is to equip the twenty thousand cars already in use in this country, running over some three or four thousand miles of track, and being drawn by some 125,000 horses, and with the system of construction which now prevails The street railroad men of all men, I believe, are hunting not only for a means of propelling their cars, but also for better means and better methods of constructing their railroads. Now, with the existing systems of construction on a large majority of the street railroads of this country you would need your flexible connection and possibly leather belts; perhaps the link belts; possibly a good combination of gears can be devised to get this flexible connection. But the other field is that of new construction, and this is the field in which I think the electricians should specially labor. They should start now and not wait five or ten years, but convince the railroad profession and the street railroad men and the street railroad builders—the street car builders, rather—that their cars and that the street railroads must be built for electric motors. (Applause.) If then they are built for the electric motor, we can supply them with something which is perfection, which will entirely do away with a great many evils which necessarily exist with horses, and with every other means of drawing and propelling the cars, even to the cable (the cable has a limited field, it cannot operate branches successfully) and a variety of other ways which I will not speak of here. But with the electric means in the construction of new roads due to the marvellous flexibility of electrical application to street roads, there is no known or conceivable difficulty that electric motors and the application of electricity cannot successfully eradicate and overcome. (Applause.) So, then, with this simple modest thought that the electric railroad men and the profession engaged in that work will impress upon the minds of all street railroad men, and all men interested in street railroads, that their roads in future must be constructed from the very outset for the application of electric motors, no matter by what system, but by the application of electricity,—then I think, and by that means only will we come to the general and successful application of the motors to every railroad throughout the country. (Applause.)

Mr. Mailloux:—There are two points which I wish to dwell upon in what Mr. Mansfield said. I would begin with the last, although it may not be proper. He speaks of the correct method —evolutionary method of the electric railroad as being that in which the electrician anticipates all that now hinders him and warps him in the development of his problem by beginning from the very first, from the outset, to prepare the road for electricity, all its appurtenances and everything else. That is a conclusion that has already been arrived at in reference to electric lighting. You will find that in the new buildings, the latest large houses, factories, etc., we need no longer go to the laborious process of drawing wires through, or taking them up to the ceiling; but we anticipate them by preparing for any system of electric lighting and place wires inside of the ceiling instead of having to run them outside. (Applause.) There is an exact analogy to the remarks of Mr. Mansfield. I was very much pleased to hear Mr. Mansfield speak. I wished that he had permitted himself to go more fully over some of the fine morsels and choice bits with which he could treat us from his stock of experience. Mr. Mansfield has been intimately engaged in the study of electric railroading for at least four years past, and I do not think that there is anybody here who is better posted in regard to the intricate details and complications of the problem than he; (hear, hear;) and I have heard him speak particularly of that very question of transmitting power from the motor shaft to the driving shaft, and he made some very pertinent remarks in a previous meeting before another association on that subject, and I think it would be conducive to the general information of us all if he would briefly review what he said then, so that it may be published with the remainder. I have reference particularly to the methods he spoke of in connection with round belting, etc.

Mr. Mansfield:—Mr. President and gentlemen, I must confess that I am considerably abashed at this method of treatment by Mr. Mailloux, and I did not come prepared to make any remarks at all, but simply to gather in all the points and all the morsels of information which I felt would be distributed and lavished with a free hand upon all who were present this evening, and I feel that any remarks or any repetition of what I have said before, in regard to the methods for connecting the motor to the driving wheels would be almost a waste of time; and there are many other most valuable points which we can discuss, and perhaps discuss with more profit and in more general ways. I spoke that evening—it was up at the American Institute, the meeting of the electrical section there—and simply gave an illustration, by means of diagrams, and very casual remarks of the different methods which had been used so far as I was familiar with them; and I can merely repeat if you so desire just those methods which I then presented; but I do not wish to discuss the efficacy of any single one of them. I said then and you can take that up if you please, that the most primal and the most perfect method obviously would be the application of the armature to the driving shaft direct. That does away with every particle of gearing. This method has been utilized by Mr. Daft in the Enos elevated railway system, which system has two driving wheels, with their shafts extending on each side. The armatures are keyed directly on the shafts. Of course the periphery of the driving wheel is small to allow a greater peripheral speed of armature. It was calculated for a certain speed, twelve to fifteen miles an hour. The main difficulty which I think there is in using this direct gearing now is simply a constructional one on an electric basis. The ordinary horse car wheel, if I remember rightly goes only some ten or a dozen revolutions a minute to accomplish the average speed upon the tramways. Now to construct a motor or an armature to go at that slow rate of revolution and develop any power you would have to go to just the extreme which Mr. Van Depoele mentioned and construct a pretty large motor. If you go into the electrical portion of it you will see that you must have a certain length of wire upon your armature to get what we call counter-electromotive force, and to do that at so low a rate of speed you would have to construct a rather large machine. Then there is of course the simple pinion upon the armature shaft, meshing into a large gear which is keyed upon the driving axle. That method is simple, but it has its objections, although if the mechanical details are properly carried out and carefully attended to and well proportioned even up to as high a ratio as eight to one or ten to one, I think that a very successful application can be made, and that is the device used on the Baltimore road. Worm gear can be used which is equally as simple as a pinion within a gear—well, it is equally as simple, but it is not as economical. The action of a worm in a gear is we have always been told a very brilliant method of losing power—that as high as thirty, forty, fifty, and even sixty per cent. of power is lost, due to friction of the worm within the gear; althought Mr. Reckenzaun, I believe, states that he has constructed a worm of a very high pitch and has contructed his gear to match, and that he gets a very slight loss, 15 or 20 per cent. if I remember rightly—I think he has figured it down to that—running in oil. Now then we go from that simple process to another, which brings in another factor and that is the introduction of a counter-shaft. We can drive from a pinion upon the armature shafts to a gear upon the counter-shaft, and again from a small pinion to a large gear upon the driving axle. Of course any little difficulties which were apparent in the previous case, would be increased in this case by the introduction of another gear. The noise, however, could be cut down by using leather belting; and there are a variety of leather belts—round, flat, angular and link belts, that have been proposed, which would take the rapid revolutions of the armature shaft and carry them to the counter-shaft with very little loss, and with not much noise, and then the slower running counter-shaft, with a pinion upon that, running the slow gear or slow driving axle can be arranged very easily, and will run with scarcely any noise, and with very, very little wear. The flexibility of this system then would be between the armature shaft and the counter-shaft, provided you wish to establish flexibility.

Now, of course there can be different modifications of this even, and I believe that I noticed in an electrical journal a description of one used by an inventor out west, in which he used a train of gears very similar to the gears that are on the lathe in the ordinary machine shops. That I believe is the perfection of complication and I do not know that I can go beyond the mere mention of it. So, with just this brief resumé of the various methods with which I am familiar that have been in practical operation, I should mention, perhaps, before closing, a method of direct running with no intermediate gearing, brought out recently by Mr. Stephen D. Field. In this a crank arm is used on the end of an armature shaft, the wrist pin of which is attached to the connecting rod. That certainly does away with all intermediate gearing, and if he can successfully cut down the revolutions of his armatures to apply it to a street car, with all the street car difficulties of going so exceedingly slow, as to just creep in the rear of a mule having two tons behind him and a very cross-grained disposition in front, if you can cut it down to that slow rate of speed, of course for tramways there could be nothing much better. But there is the "if" to conquer. For lighter suburban ways, where you have the right of way and where you wish to run at a rapid rate of speed, where you connect two places, one of business and one of residence, where the business man who has been laboring five, six, or seven hours a day down at his office wants to get home at the rate of two miles a minute to see his family and get something to eat, of course then the direct application is superb. (Applause.)

The Chairman:—I believe I voice the general desire in calling upon Mr. Field.

Mr. Field:—I thank you for the compliment. Replying to Mr. Mansfield's remarks, there are two ways to supply the speed of armature necessary. One is to confine yourself to the ordinary two pole machine, using a great deal of wire and iron, the other is to increase the number of poles of the machine. That I have accomplished and with only two brushes. Then again with regard to the conduits for city traffic I propose in introducing electrical traction on a line already established,—where the rails are laid on longitudinal sleepers—to take these sleepers out bodily and put in their place a hollow cast-iron girder, the top of which is capped with a steel rail with a flange carried underneath, so that you cannot get a horse's heel calk into the slot, but you can have your little carrier in there. Mr. Martin said that that was the way to carry very high potentials. I propose to carry more than one high potential, but at the same time have the minimum strain on the insulators. To accomplish this result I establish a power station at either end of the line, and carry a zinc potential in one conductor and a copper in the other. You will observe they run parallel. Now every car on the line receives exactly the same potential wherever it may be. By this means I can carry as high as a thousand volts, and with great ease. You have got to have this high potential with a great number of cars. There is no other way to do it that I can see. Then for very large motors I wish to call your attention to a little improvement. You know how they will spark unreasonably. I find that the spark is not governed by anything particularly. It seem to vary with the load and with the machine and with the man that works it. I thought I would let the spark govern itself. I have put a couple of brushes on the commutator at the neutral points and connected them with a motor, called the brush governor. As long as the regular brushes are at the proper point, there will be no current pass between those extra brushes, let the regular brushes get ever so little out of position and immediately the current commences to go through these auxiliary brushes. Force the commutator to a false position and upon its release it will automatically turn back to its true position; the result has been very satisfactory.

Mr. Pendleton:—Mr. President and Gentlemen: I felt to-night that I, as a visitor, might occupy the position that was spoken of by an eminent member of a whist club which I belonged to in referring to the gallery—that the gallery should always be silent; and I felt as a visitor to-night that that probably would be my position.

I am very much gratified at meeting here so many gentlemen I am acquainted with by name more than in person, and gratified also in having heard from Mr. Martin the excellent address which he has given to us. But in that address he took the occasion for saying that those who spoke well of the accumulator had been looked upon as knaves or fools. As the accumulator and its uses has formed the main subject of my investigations in electricity I felt that, although thoroughly consistent for the last five years in the matter, we had now arrived at a time when we could boldly face electricians and the public with the service, and the good service, that the accumulator was capable of. It is now some two years since its value in connection with electric traction came to my attention. I have appreciated and understood the remarks of our distinguished guest, M. Julien, to-night, one of the gentlemen whose name was thoroughly familiar to me as the associate of M. Camille A. Faure and whose intelligent work in the development and the application of the accumulator to traction was appreciated by us before his arrival in the country. The demonstration that has been made so far has only been thwarted by mechanical, and not electrical misfortune. I do not feel that on the subjects, to-night, which have been so thoroughly canvassed, I can give you any very interesting or pointed remarks. There seems to be nothing more to be said. But I will say that the subject of electrical propulsion upon railways is now attracting the general attention—I can speak of that—and our deliberations and the remarks made to-night will go far to instruct the railroad men of America in the fact which we have known long since, that the electric motor is the engine best adapted for their purpose.

MR. MAILLOUX:—I would like to suggest to Mr. Pendleton that he might tell us something about his system in connection with the accumulators which he has brought forward and which seems to possess some features of merit, namely, the combined conduit and accumulator system.

MR. PENDLETON:—The system which Mr. Mailloux has referred to is a combination of a conduit with an accumulator system for energizing the motor. On nearly all of the systems of electrical railway, there will be a necessity for distribution of passengers at the different termini, and it occurred to me some time ago to study up the matter in the way of refreshing the accumulator during service. Also, in the direct transmission of energy from the station to the car there is always the question of insulation and loss by resistance, which has formed a very difficult problem in many instances to solve, as we know by the experience on the different railways which have been established in Europe. But by combining the two systems, the convenience, the elasticity, will be found in taking the current directly from the dynamo, where it is the most economical, and over the parts of the line where resistance comes severely into play, the accumulator would afford for purposes of distribution at the termini, a means of propelling the car. To illustrate this more fully, I should say that a system where the charging station performed on the conducting track or conductors the double duty of actuating the motors and charging the accumulators at the same time, the accumulator itself could be made the means of governing the motor on that part of the line. When passing beyond the limit of the line where conductors existed, the chemical energy stored in the accumulator would operate the motor and at the same time be able to control it. For instance, supposing a line of twenty miles, or any other distance. A station would find difficulty, by the ordinary methods, in operating a motor located in a tram-car at that distance, ten miles on each side, from the station. But taking the ordinary variations of the line, the car would at times take seven or ten horse-power upon gradients and curves, while on the ordinary levels one or two horse-power would be sufficient to propel the car. Now, having on the tram-car the battery of accumulators, a simple system of connecting the accumulators into different combinations of two, three, and such series as would enable the electromotive force—the constant electromotive force—of the line to be varied, so that a certain proportion would be used at the motor and the balance would pass into chemical energy, and by varying in that way in going up a gradient the bulk of the electromotive force would operate the motor. In a down grade the bulk of the electromotive force would pass through the accumulators, and the ordinary accumulator, instead of operating the car under such circumstances thirty miles, might be made to operate the car for a day of fifteen hours, as when passing over the portion of the line having conductors, the accumulators would be constantly refreshed, and upon a portion combined for the purpose the accumulators would be available almost continually without stopping. That was briefly the system which Mr. Mailloux referred to, and the only matter in addition was the mechanical device which was proposed to be placed under any horse-car for the purpose of converting the cars now in existence into electrical cars, which would further the advance of the principle more rapidly than if it were required to build cars and introduce them, replacing the others. For that purpose it was suggested to my mind that by keying upon the axles a split worm wheel, a motor suspended from the bottom of the car would enable a connection by worm to operate advantageously where the dust could be prevented from entering the worms and where oil could be maintained to lubricate properly the worm and the worm wheel. Therefore keying upon the axle a split worm wheel bolted together; on the boss or hub of that wheel there was a box supporter which afforded the opportunity of placing two journals, one on each side of the worm. Both of the axles so furnished—the worms were made right and left—had reversed gears, one operating above, the other operating below, the axle. This relieved the thrust which would result from their being placed in any other way, and the friction and loss of power which the wearing on the collar would entail. The difficulty hitherto encountered in placing the motor where it would be subject to the pounding of the track seemed to be relieved by using a flexible axle. That is, on the armature shaft connecting with the shaft of the worm wheel about seven inches on each side was a spring or double spring, so that the flexibility of that shaft would allow for the difference of the load or from the wearing of the boxes. I had occasion to show the plan at the Electrical Society some time ago, and I doubt whether I have the power in language to give you a clear description without the drawing. But, so far, I have not had the opportunity of placing it upon a car, and although it has received the favorable comment of those who are expert in such matters, yet no man can promise from an idea, no matter how carefully studied, that which experiment only can prove.

CAPTAIN MICHAELIS leaving in order to take the Governor's Island boat, MR. MAILLOUX was called to the Chair.

MR. MAILLOUX:—We have with us this evening one of the gentlemen who is interested in financiering in connection with these matters—General Stiles, the treasurer of the Van Depoele Company, and I have no doubt he can give us some very interesting details and statistics—tell how much the roads are being run for and other matters of interest.

GENERAL STILES:—I presume that some one was laboring under the impression that I was an electrician, and I beg to assure you that I am not, and I know but little about electricity. Still, I think if I could get the worthy Chairman to interpret for me I might make a tolerably fair speech. I do not think I could say anything that would be of interest to you in the line that should be discussed here to-night. I simply know that with the Van Depoele Company we are operating some six roads every day. Our road is in operation at Scranton, and we would be very glad to see any of you there who desire to examine it. I have had great faith in electricity as a motive power and I have invested considerable money in it; and I have faith in electricians, especially Mr. Van Depoele. As I said before, I know absolutely nothing about electricity, and how little I know, perhaps, I could illustrate by a little anecdote. A young gentleman called on me a short time ago to engage as an electrician. He gave me his card as an electrical engineer. I asked him what he knew about electricity, and he said he knew all about it. Of course that satisfied me as it would anybody that was interested in the business; and I told him that I knew there were electricians and electrical engineers, but I had very grave doubts whether there was any such thing as electricity; and he attempted to convince me that there was, but failed, and left in disgust.

Gentlemen, I thank you for the honor conferred upon me in asking me to speak, but I really don't think there is anything that I could interest you with at all.

Mr. Martin:—How many miles of track are you running?

General Stiles:—I think we were figuring it up the other night—something like thirty miles.

Mr. Martin:—Every day?

General Stiles:—Every day. We have six roads; and what I consider the best part of it is, they are all paid for.

Mr. Martin:—How many cars?

General Stiles:—About twenty-eight cars. The road that we were running at Minneapolis is being run by steam cars. The cars were ordinary cars, the same as steam cars. We put it in as a temporary affair, to enable the company to run their cars until they could get some ordinance to allow them to run by steam. However, they have offered to purchase the apparatus of us, but they have had some misfortunes, especially in the soda-motor line. They were trying to operate four soda-motors made by the Baldwin Locomotive Works. The last time I was there Mr. Hill, the engineer—there were four boilers built by the gentleman—Mr. Hill called my attention to the coal on the floor, about two bushels. He said that was the last of thirty tons they had used to charge that one motor with, and they had not started it yet. So I concluded that there was something else required.

Mr. Mitchell:—I have heard about some "Great Eastern" motor at the Rhode Island Locomotive Works, in Providence. I understand there is a very large motor being built there, and I would be very glad personally to hear more about it.

The Chairman:—I can state for the information of the gentleman that I was in Providence recently on a tour of examination of that particular system, and that at that time the motor was still on paper. They have a motor with a capacity of fifty to seventy-five horse-power for street traction; but they had not yet begun to work on the large electrical motor—that 600,000 watts motor which I understand you mean.

The Secretary read the following communication from Mr. R. M. Hunter:

No. 926 Walnut Street,
Philadelphia, Dec. 6th, 1886.

Ralph W. Pope, Esq.,
Sec'y American Institute of Electrical Engineers.

Dear Sir—

I expect to be present at the meeting Dec. 7th, but should I not find it possible, I would request you to state to the meeting that I find the prejudice against the practicability of electrical propulsion, which was so strong several years ago, fast disappearing, and that it is now the first thought as a possible motive power. My experience as expert for the National Cable Railway Company has satisfied me that cable traction is doomed, and that many of the cable railways now in existence will be converted into electric roads. This inclination was in existence even in 1883, when I had a project under consideration to convert the Chicago City Railway into an electric railway, and so far back as 1881 I endeavored to induce the Union Railway (now the Traction Co.) of Philadelphia to adopt electricity in place of their cable railway then building on Columbia Ave. The Cable Company is inclined now to believe in the change. At the present time the Hunter Electric Railway Co. is estimating for the construction of four roads, aggregating nearly twenty miles of track, with 110 motors, located in Pennsylvania and New Jersey. It is also negotiating for the equipment of a road in Massachusetts and a sub-company for that state, and another in Pennsylvania, aggregating at least thirty miles of track. The prospect for the introduction of electricity for street car propulsion is very flattering.

Very truly,
R. M. Hunter.

After a few remarks in favor of continuing the special meetings, a motion to adjourn was carried.

Special Meeting.

February 6th, 1887.

The Special Meeting for the consideration of "The Practical Requirements of Small Motors" was held at 130 Broadway, New York, at 7.30 P. M., February 6th, 1887. In the absence of the President, Mr. Sidney F. Shelbourne was invited to take the chair, who announced that Mr. Schuyler S. Wheeler would read a paper upon the subject for discussion, which would be accompanied by an exhibition of the working of the motor.

THE PRACTICAL REQUIREMENTS OF SMALL MOTORS.

BY. S. S. WHEELER.

It is a remarkable fact that not only have none of the small electric motors thus far put upon the market been constructed on the same principles as those of an efficient dynamo machine, but no attempts seem to have ever been made to copy large machines in the very features which are known to make them efficient and practically serviceable.

Any electrician, in looking at the motors heretofore offered to the public, can see at a glance why they cannot have a good efficiency, why their resistances are necessarily high, why they have to be run at too high a speed, or why their commutators will spark badly and quickly wear out, and why it is entirely out of the question to use them for giving power in thousands of cases. And yet, notwithstanding that these objections are almost entirely removed in large motors built exactly like large dynamos, no small motors have ever been manufactured before, which are any approximation to the larger machines in these important respects.

Probably the most important reason why so little attention or electrical ingenuity has been given to the subject of small motors is that the energies and inventive faculties of electricians have for the past three or four years been devoted to the problems of the transmission of large amounts of power, and especially the propulsion of street cars, etc., which present great difficulties, but difficulties that electric motors are especially suited to overcome.

The natural result of this prospective demand for such sizes and kinds of electric motors as this work will require, has been the diversion of the best electrical talent in this direction, and the consequence has been the production of such machines, almost perfectly adapted to the requirements.

Meanwhile the subject of small motors has lain comparatively unnoticed. Each isolated want is of less importance to the user and of less value to the dealer than in the case of a large motor; in other words, as the small motor to be successful must be cheap, and the power to be supplied is small, there is little money in each individual case, and it is only when the number of individual users gets to be large that the matter of small motors becomes a promising field. It does not follow, however, from the lack of attention bestowed upon the subject, that there is no field for such work; on the contrary, there is an enormous number of individual instances where an electric motor would certainly be used if it be just good enough to come within the requirements.

In addition to the ordinary uses where we regard a motor as simply the best means of obtaining power for a certain purpose, for example, the running of a large number of small machines in a factory, where the motors and feeding wire take the place of shafting and belts, there are many places where the work would not be practicable without one, and where a motor, therefore, would be said to create the use. Such are all uses of very small amounts of power where an engine cannot be run, and which are beyond the capacity of a man at a treadle. There is a large class of uses for power where a steam-engine is not admissible, and where a good electric motor on a circuit is the only alternative, and in the absence of a motor good enough to be safe on an electric light circuit, or efficient enough to be run economically, all these industries have to be conducted in other ways, to avoid the question of small power distribution.

The response to the demand for electricity for lighting, has been the production of dynamos of ninety-five per cent. efficiency, a far better result than is obtained in steam-engines, and conversely these dynamos can be used as motors with the same efficiency. But the result of the needs of electric lighting, in response to which demand these dynamos have been created, is that they are machines of large power, and so in these we have motors of large power without further change, save as to means of regulation.

Now why is it that we have not already had for some years motors of very small power, and reasonably near the same perfection of efficiency?

It is because a small motor while requiring the electrical construction and efficiency-giving features of a large dynamo, to be equally efficient cannot, for several reasons, be made an exact miniature of the large dynamo in mechanical construction.

If you want a 1,000 horse-power engine, you will get a Corliss engine, with elaborate valves, adjustments, etc. But if you want one of one-horse power, you will not get a miniature of the Corliss engine, requiring an engineer to take care of it. You will get a Baxter or an oscillating cylinder engine, with no external valve gear or adjustments, which will almost take care of itself. You must, to make a small motor successful for such practical purposes as it is to be used for, reduce the complication of its parts and its liability to get out of order.

Of course, this is realized by every one who has given the subject any consideration, but, nevertheless, the practical result has been that the only small motors thus far produced have been made apparently without any analysis of the difficulties to be met and any consideration of the means for overcoming them. Many of these motors have been so entirely unsatisfactory that they have been looked upon as little better than toys, and have reacted discouragingly upon the public.

Some of these motors, if placed on an incandescent circuit, for which they are intended, will burn themselves up. Others are of such very low efficiency compared with dynamos, that they require treble and quadruple the amount of current to give the necessary power. This is the principal reason why small motors, run from batteries, have not been more successful heretofore. The batteries have not been particularly bad, but the motors, instead of making good use of the current furnished, which is costly at best, have simply slaughtered the battery when pressed to do the work, by drawing four times the amount of current which would do the work, if efficiently used. I refer, of course, to the failure of the motor to give a counter E. M. F. when running, to which is due this inefficiency. The E. M. F. generated by a machine when driven as a dynamo, is the real test of its efficiency.

In order to get counter E. M. F. or magnetic effect, which is the same thing, and which is shown by running the motor as a dynamo and observing how much current it will *generate*, it is necessary to have a strong field, a large number of convolutions on the armature, and high circumferential speed, all of which are interchangeable as factors; while at the same time the resistance of the wire and the speed of the armature must be kept down. The first is necessary so as to permit strong current effects to be produced and large power to be exerted when the motor is running slowly, as well as to reduce the loss from the internal resistance of the machine; and the second, to avoid high working speed, which is always undesirable, for mechanical reasons. It will be observed that all of these requirements tend to the enlargement of the machine, especially of the armature.

These considerations lead to the conclusion that it is better to make the armature a little larger proportionately than it is made in large machines, in order that our very small motor may still have the proper amount of wire, etc., in the armature, and be a true dynamo, capable of giving a proper E. M. F., instead of being a mere electro-magnetic engine. By so doing we also make the armature much easier to manufacture.

There is now before the public a small motor, of which we have some specimens here to-night, in which the armature is enlarged radially, somewhat out of the usual proportion of armature to field, whereby the comparative strength of the field is perhaps reduced a little; but the armature capacity is increased in a much greater ratio, and consequently the E. M. F., or magnetic pull of the machine is large, and the internal resistance, as well as the shaft speed, is small. In addition to this departure from the usual proportion in order to meet the difficulties of small motors, there are a great many special features to increase the convenience as well as the efficiency of the machine.

As I believe this motor to be the first one on the market giving an efficiency corresponding to large dynamos, and at a price proportionate within 25 per cent. of the established prices for large machines, I think a description of it will be of interest. (I may say here that later on some tests will be shown, and an opportunity will be given of examining the motors and apparatus.)

The field magnets are of the simple horse-shoe shape, and the armature is a Gramme armature of comparatively large diameter and short length. The Gramme ring gives room for a large number of windings, with small mass of iron to be magnetized, and the large diameter, compared with the length, gives greater circumferential speed, with the same windings and mass. The cores of the field magnets are of best wrought iron, $1\frac{1}{8}$ inches in diameter and three inches long. The yoke and pole pieces are of equal section with the core, as is also the armature core, thus forming a magnetic circuit all around the horse-shoe and across the armature of uniform conductivity. The yoke and ends of the cores are cut clean by machinery, and firmly bolted together, and the iron fibre of the pole piece continues up into the core, both being in one piece and of equal section. The non-magnetic base plate extends around underneath, and forms a clamp for fastening the whole motor firmly to the edge of a table, a point of great convenience.

The armature is built up of about forty semi-circles of thin sheet iron, riveted together with two long rivets, into a solid ring, hinged on one rivet, so as to open on the opposite side to receive the winding. These thin laminæ of soft iron are separated by tissue paper, to prevent the generation of Foucault currents, precisely as it is done in the largest and most efficient dynamos. The complete armature winding, previously formed by automatic machinery, is slipped on to this split ring, which is then closed, the open ends of the half circles fitting into each other when brought together, forming a mortised joint, which is then secured by driving a final pin or rivet through them. When this hinged ring is closed, the core forms a hollow cylinder three inches in diameter, $\frac{5}{16}$ inch thick, and two inches long.

The armature winding consists of a flat wire or ribbon, wound on edge into a single helix, the full length of which equals the circumference of the armature. The commutator, which is of the disc type, consists of seventeen copper sectors riveted to a fibre washer. The latter is attached to a cylindrical wooden block which is turned true with the shaft of the motor, and to a tight fit for the inside of the ring, after the winding has been slipped on it. This block and shaft are then forced into the centre of the ring, until the outer extremities of the commutator sectors are brought within about $\frac{1}{8}$ inch of the winding on the ring. The claw-shaped outer tails of the sectors are then bent together, pinching tightly certain loops of the armature helix, which project out further than the main body, for this purpose.

These high convolutions or loops are then soldered to the commutator strips, making a solid and extremely simple and reliable connection.

The armature shaft is mounted in bearings, which are screwed to both sides of the pole pieces. The brushes are each held by a single screw, which also makes the connection with the leading wire, and, with the co-operation of the bearing plates, holds the brush at the proper inclination. The armature of this motor has room enough for a winding, such as described, composed of 204 convolutions and of sufficient conductivity to carry twenty amperes, half of the current passing around each side of the armature. Therefore, we may say that the magnetizing capacity of the armature winding is 2,000 ampere turns. Of course, the size of the wire in the armature may be changed to suit the circuit, so as to give a higher E. M. F. and less amperes, and still utilize the same amount of volt-amperes within this limit. Thus we may substitute for the 204 turns on the armature, 408 turns of wire of half the size, and still get the 2,000 ampere turns, when used on a ten-ampere circuit. The field is wound so as to carry the same current. The company is at present winding its motors with three styles of windings; the style designated A. is adapted to be used in 20-ampere circuits, such as the United States Co.'s arc light circuits; another style, designated type E, is wound for 10-ampere circuits, such as the Brush arc circuits; and the third style, designated L, is wound for 100-volt circuits or thereabouts, such as the Edison incandescent circuits.

In regard to the power and efficiency of these motors, I have found that when running at 1,500 revolutions per minute—a moderate speed for motors of this size—and, therefore, taken as the basis of tests, the 20-ampere motor, or type A, with 20 amperes passing through it, shows a difference of potential between its binding posts of 7 volts—5 volts due to counter E. M. F., and two volts due to resistance. This means 140 volt-amperes consumed in the motor, or a little more than one-sixth of an electrical horse-power. Under these conditions a Prony brake shows a pull of five ounces on a one foot lever; that is two foot-pounds per revolution, or about one-tenth actual horse-power at 1,500 revolutions per minute. The windings for other circuits give results to correspond. Therefore, when the motor is running with all the current it can carry, it uses about one-seventh horse-power of electrical energy, and gives about one-tenth horse-power of useful power, or 50 per cent. of the energy used, allowing for slight additional losses, which is about double the efficiency of any small motor which I have examined. And this performance is with a current heavier than can be carried by other small motors.

When running with about three-fourths of this amount of current, or about 15 amperes, the efficiency is considerably greater, reaching about 60 per cent. This is the best working load for the motor, because the loss by resistance of the machine is less. But when we get down to about seven or eight amperes we find that the efficiency falls again, owing to the approach to the limit of weakness in the field. And when we reach four amperes, we find there is just field magnetism enough to turn the machine.

The loss of this initial current of four amperes in charging the field, is unavoidable, on account of the necessity of having enough mass of iron in the field to use the full two thousand ampere turns that the motor has, when fully charged, without bringing the iron too near the point of saturation, or, in other words, to make the motor large enough to use ¼ h. p. of current, without passing the point of saturation. Hence we see that if a motor is intended for use with a small current, it is better to make the field magnets of smaller diameter. This is another illustration of the difficulties to be met in making motors which will be good under varying loads.

In regard to its use as a generator, the motor with 20-ampere winding will give about 5 volts when running at about 1,500 revolutions per minute, and as its current capacity is 20 amperes, this means, allowing ½ volt lost by resistance, 90 watts, or about ⅛ h. p. of electrical energy in the external circuit. That is, enough to light a 16 candle-power lamp. By changing the size of wire and putting on sufficient convolutions to get a high E. M. F., we get a generated current of 1 ampere and 90 volts, sufficient for a 16-candle light, with a consumption of ¼ actual horse-power.

As the motor was originally designed for domestic use in running sewing machines with a battery, the current from which is necessarily very expensive, great stress was laid upon designing it so as to make the very best possible use of the current, for the sake of economical running, and also to make the motor as small and light as possible with the capacity required.

This latter consideration led to the immediate determination to use the very best wrought iron, and it is only by making these necessary elements of good construction, the first consideration in their manufacture, that a motor of this surprising efficiency has been produced.

In proof of the correct design and success of these motors, it may be interesting to hear that the semi-automatic machinery which was originally made for their manufacture has been kept in operation continuously for the last three months without interruption, and that already over six hundred of the motors are in use.

DISCUSSION.

THE CHAIRMAN :—I understand that Mr. Diehl is present with us this evening, who has had considerable experience and is acquainted with the details of the operation of motors and we should be very glad to hear from him.

MR. DIEHL :—I am not an electrician, but a sewing-machine man. I have, however, made some experiments with small electrical motors, and have made them of various styles. Some time since I placed one of them upon the market, but since then have made a number of improvements, and have come to the conclusion that the armature in small motors should have more sections than the one spoken of, which had only four. I have recently produced an improved motor intended more especially for sewing machines, the complete motor being housed within, or in direct line with the balance wheel of the machine and adjustably connected to the driving shaft. There is a great gain in this manner of connecting the motor, as no belt is required and therefore the friction is largely reduced. The armatures in my first motors were too small. I have found that they should be larger. I have built Gramme armatures, and think that for a small motor a diameter of three inches is a good size.

The motor which I intend for a sewing-machine exclusively, is entirely within the wheel of the machine. The armature is a Gramme ring, made in two sections. It is located by screws, so that it can be centralized. I have a field magnet in the inside of the armature. This gives me very good satisfaction. The wheel and motor together weigh about five pounds. The wheel is merely the housing for the motor. For fans and such purposes, I have built it in a different shape, but I also use the Gramme ring. I have come to the conclusion that it is a better shape than the H-armature.

THE CHAIRMAN :—Do I understand that the armature of the motor and the wheel revolve on the same axial line?

MR. DIEHL :—Yes; the armature is in the wheel; fastened to the shaft. It can be released from the shaft for winding bobbins, so that only the wheel with the armature revolves.

THE CHAIRMAN :—Is there any difficulty in placing more divisions on the commutator than before? I understand that the C. and C. motor has seventeen. Why not double the four in your case?

Mr. Diehl:—Well, I have from 12 to 34 sections in the wheel motor; in the earlier motor I had only four sections.

Mr. Mansfield:—Mr. Chairman and gentlemen: I certainly would speak most heartily in commendation of the ingenious methods which the C. and C. Company have adopted and devised for overcoming some of the most difficult mechanical questions which existed in the early constructions of small motors. I do not know but that the main reason why the Gramme ring was not used for small motors at an earlier date was the fact that the armatures could not be wound cheaply enough to answer the purpose. They had to thread the wire in through this little ring and out again by hand; and the method adopted by the C. and C. Company has certainly overcome that difficulty in a very nice way. I think that in overcoming that difficulty they have started in on a motor and on a theory, viz.: that small motors can be built just as efficiently as large motors,—and there is hardly any reason why they should not,—which if carried out will bring success. But yet, if the analogy can be carried out, we all know that small steam-engines cannot be built to operate as efficiently as large steam-engines.

The Chairman: I think that if fifty years ago, somebody had said to a Geneva or London watch-maker, that in the years 1884 to 1886, watches could be made so cheaply that dealers could give a Waterbury watch with $12.00 worth of clothing, they would have thought it was practically impossible. Certainly the price at which they make and sell these motors would indicate that perhaps further on they would be able to give them to some of these clothing dealers so that they can give a motor for every $25.00 worth of clothing, anyhow.

We would be very glad to hear from Mr. Wing, in regard to the application of motors.

Mr. Wing:—I would prefer to listen a little longer and to ask a few questions before undertaking to address the meeting at length. One of them is the question of batteries—primary or secondary or any other kind. Are there any persons here prepared to answer as to any of the existing batteries being practicable for long periods of time, so that the purchaser of a small motor can afford to run it? I have investigated quite a number, and so far, none of them have proved satisfactory. I would limit the question to three horse-power—one horse-power will do. If I sell a sewing machine or a fan or a lathe or anything else, I want to know commercially how long I can guarantee that battery to run and how much it will cost to run it per day, per week or per month.

Mr. Bradley:—I have experimented considerably with a certain line of storage batteries. The storage batteries which I have worked upon are bromide of zinc and there have been certain difficulties to overcome in order to make them practicable. I never have placed them on the market. Of course this battery is very different from a lead battery, being free from some of the difficulties that are involved in a lead battery. But the specific resistance of the liquid is pretty high, which makes it rather inefficient unless the liquid spaces are very thin.

Mr. Wheeler:—I might perhaps give you some figures about the batteries we are making; but I think on points of exact science, the cost of running them, etc., I should refer you to Mr. Crocker, who is one of the chemical experts of the company, and who has more figures in his head than I have. I might say, however, that our battery is an electropoion battery; no porous cup. Instead of using carbon plates, we use pencils. We use the regular electropoion fluid, except that it is a solid—here (exhibiting), is some of the material, and if we add pure water to that and analyze the solution, we will get almost exactly what electrical dealers call electropoion fluid. We use no larger jars than in a Bunsen battery. The amount of chemical energy in this solution is just the same as it is in the same volume of the ordinary electropoion fluid.

Mr. Wing:—I have found this difficulty in all those batteries with which I have experimented, that when you come to take them up commercially, there is the inconvenience of emptying the jars and replacing them.

Mr. Wheeler:—It is giving that point due consideration which has led this company to produce a battery jar, which has a very suspicious appearance—(exhibiting jar). As that has about a tenth of a horse-power hour in it, I do not want to upset it.

Mr. Mailloux:—How many sewing-machine hours has it?

Mr. Wheeler:—It has about six sewing-machine hours. The electro-motive force is three and nine-tenths volts; the internal resistance is about 5-100 of an ohm, when you begin to use, up to about 15-100 of an ohm when the solution is mixed up with the acids of the action and when the resistance is therefore higher. The fair average is about 1-10 of an ohm internal resistance and the capacity of the battery is 12 amperes. It will keep on furnishing 12 amperes without declining until the chemicals are all used up. If you short-circuit the battery it will give more amperes than any other battery of equal size that I have ever seen. I have an amperemeter that will measure up to 45 amperes and it will give more amperes than that will register. It will give about 50 amperes on a short circuit. Of course it won't keep that up more than three or four minutes, because the solution will not circulate fast enough to bring fresh material up to the zinc in time. It will stand 20 amperes for five or ten minutes, but it will stand 10 amperes and trot right along without minding it at all. It does not furnish 12 amperes to run a sewing-machine for six hours, because a motor when running a sewing-machine will use only about 8½ amperes. Of course the resistance of the motor alone, without any counter E. M. F. will allow about three times that amount to flow. It takes two of these jars to run a motor at a lively rate and do work; one will run the motor alone.

MR. WING:—Suppose you want to run five or six hours during the day and eight or ten hours at night; how many cells would it be necessary to have, and how long would these cells last without replenishing? I do not mean to run right down to the hour.

MR. WHEELER:—Do you mean continuous running? You know if you give the machine to a person it will be said that it is used continuously. The facts are that they sew for a minute; then they stop to shift the direction of their seam, etc., and the electricity is not used up. I have to make that distinction, because an absolutely continuous run is a very different thing from a human-being run, so to speak.

MR. WING:—I am getting at the actual run—four hours during the day and an eight hour run at night.

MR. WHEELER:—I think you would be obliged to have jars about twice the size of this. Of course, if you were not going to do the work at any greater rate than this, you could use the same solution and simply have larger jars. If I were going to do it, I should have another pair of jars ready and slip them in when the first were exhausted. It is only a question of having enough solution there to keep it up for that length of time.

MR. WING:—My experience is that I cannot sell a machine to run by these jars in the ordinary form for the simple reason that people have to change them too often and it is too much work to change them. In running a sewing machine, as Mr. Wheeler observes, they run a minute and then they do not run a minute, and sometimes do not run for ten minutes; but when you come to put this same motor upon a machine that requires continuous running it is a different thing. The fan is probably the worst thing you can put on to motor, because it is a dead pull from the time you start it. Now, we sell largely for that purpose, and they are required to run about four or five hours for office business. Many thousands could be sold for ventilation of private residences, sleeping-rooms and uses of that kind, if we could get a battery, or if we could get the power at a moderate price to run these motors during the sleeping hours—say eight or ten hours, but it must be a steady run.

Mr. Pendleton:—I think if a power circuit was established there would be no difficulty in running either a fan or sewing machine satisfactorily. At the present time you are obliged to do what you can with the best batteries in existence at the present day.

Mr. Wing:—I am told that there is a party in Brooklyn who thinks he has what is a primary and secondary battery, so that by a change of wire you can get what you want.

Mr. Pendleton:—If you were in the city of New York, I do not think there would be any difficulty in supplying you to-day with what you require. I guarantee that you could be fitted out to use secondary batteries with good results. The electro-motive force supplied is low enough, and you have merely got to create the proper facilities. The current is supplied from a dynamo and you can run anything from a C. and C. motor up to a ten horse-power.

Mr. Wing:—That covers a few blocks but we want to cover several states.

Mr. Pendleton:—The only way then is to give them proper encouragement to go further.

Mr. Curtis:—I think the kind of fans Mr. Wing refers to chiefly, are fans that require more than half a horse-power to drive them.

Mr. Wing:—No sir; a thousand could be sold for that purpose at about one-eighth to one-fourth horse-power for sleeping rooms. This motor has got the power for that purpose, as I can see from the speed at which it runs the fan here. One-eighth or one-fourth of a horse-power will do very well for sleeping-room purposes and thousands will be sold for that alone.

Mr. Curtis:—The power of one of these batteries is 1-40 to about 1-50 of a horse-power. Now if you want 1-10 of a horse-power you would require four to six of these batteries. A tenth of a horse-power on a small motor is a good deal more than you would expect. When we were running it here, we were running from the Edison circuit, and were taking about as much current as one of these lamps takes—we were taking a little more; we were taking about a tenth of a horse-power.

Mr. Wing:—A tenth of a horse-power is ample for the purpose I referred to.

Mr. Curtis:—The question is whether, somewhat less than a tenth would be enough.

Mr. Wing:—It would be for smaller rooms.

Mr. Curtis:—When we took up the problem we found that there was not any battery in the market which, unless we used a good many cells would give anything like the necessary current. Now, the only way to get the power out of that battery is by fulfilling two conditions. In the first place, it is necessary to have large plates so that you do not draw a heavy current from small surfaces. In addition to that, you cannot have a very low resistance. As soon as the resistance of the battery comes up, you have got to increase the number of cells. The resistance of one of these cells is only 1-20 of an ohm; which is ridiculously low for a battery of that size. There is no battery made to-day which is as low as 1-20 of an ohm per cell, except a very large plunge battery. Now the only battery which would take the place of this and that would give the same volts and amperes before we devised this, was something like a Bunsen battery or an ordinary plunge battery. The difficulty with the plunge battery was that it would not maintain the current; there was no circulation of the liquid; and then if we put the plates nearer together we could not maintain the action, and we had to stop and give it a rest and then start off again.

Mr. Wing:—That has been my experience with all that I have tested.

Mr. Curtis:—That is eminently the case in any form of battery where provision is not expressly made for circulation. In this battery we can get about one ampere from about a square inch of surface. You take a battery with a porous cell in it, or an ordinary plunge battery, and it will have perhaps 12 square inches to the half ampere. This battery will give from five to ten times as strong a current for a given area of zinc as any battery I know of. We seem to have got as near the limit of lowness of resistance as possible, because unless you can lower the specific resistance of solution, you cannot bring your plates any nearer; there is nothing intervening which you can take out and you have got the resistance as low as you can get it.

The only way in which you can get power enough out of this kind of battery to give you one-tenth of a horse-power is by adding cells or making larger cells. Now you can do that easily enough. But nevertheless it involves having the cells four times as large or having four times as many of them. Then the domestic conditions come in; perhaps you can use it, perhaps you cannot. There is no battery at all, that it is worth while talking about for one half a horse-power, entirely irrespective of the cost of solution. The solution is a costly thing anyway. Now that battery will give a fortieth of a horse-power continuously for six hours. That requires one change of solution, and one change of solution costs about thirty cents. So it costs thirty cents for six hours.

Mr. Wing:—When you come to put one-tenth of a horse-power on and run eight hours, it makes the service very expensive.

Mr. Curtis:—Well, there are wealthy people who do not care about the cost of solution so long as the battery is easy to take care of.

Mr. Wing:—But they are obliged to have so many that it is a serious objection.

Mr. Curtis:—There is no difficulty in obtaining all the power you want if the electric light circuits are there. We anticipate that all cities are going to have arc or incandescent circuits for domestic use and we propose to put our motors on those circuits. You can put one of these motors in the place of one of these lamps here, as we do now, and it will give you a tenth of a horse-power.

Mr. Wing:—Do you intend to build your motors for arc circuits?

Mr. Curtis:—Yes: we have some already built. They are boxed up to protect them—that is to protect the people outside of them from touching them and getting a shock.

Mr. Wing:—Do you require any resistance coils?

Mr. Curtis:—We have a shunt which controls them. They have a multiple arc with a variable resistance.

Mr. Wheeler:—In that box you can get the power from a wooden pulley and you cannot get killed.

Mr. Mailloux:—In reality, the current given to the motor is merely the difference in potential between the two ends of the shunt?

Mr. Curtis:—Exactly. We have got, perhaps, forty or fifty horse-power going through the circuit and you cannot change that very much. Now we make these motors up to two or three horse-power.

Mr. Wing:—Have you already made them large?

Mr. Curtis:—We have made some. We are not quite satisfied about the commutators yet. But they give very satisfactory results. At present we propose to apply them especially to fan work.

Mr. Wing:—I have understood that you have already put some on the Brush circuits. Have you arranged with them as to charge?

Mr. Curtis:—In some of the cities we have.

Mr. Wing:—In New York?

Mr. Curtis:—No; I do not think we have arranged in New York yet. The Brush people are trying it now. Mr. McGrath, who is superintendent of the district in New York, is trying it for his own station. I believe he says that he thinks they are just what are wanted for their circuits.

Mr. Wheeler:—Mr. McGrath reports fifty-five per cent. efficiency on his circuits with this motor.

Mr. Wing:—He told me they were prepared any time they had a motor that was satisfactory to them, to put it in; I understand that in Baltimore the Brush people have agreed to furnish power to the Baxter Motor Company at five dollars a month. They are doing it right along all the time—for one horse-power or ten little motors at the same rate. They are putting them in a great many places where they are using sewing-machines. They put a small motor on each machine.

Mr. Curtis:—I am not sure but what the Daft people furnish a horse-power at six dollars a month.

Mr. Wing:—I think they charge altogether so much a month. motor and all. At least that is the way they serve us.

Mr. Martin:—In Philadelphia there are about two hundred motors on the Brush circuits, some Cleveland and some of them Edgerton. I think on an average they get about four dollars a month. Mr. Law is running about sixteen of them with the current of an arc lamp.

Mr. Mailloux:—I have recently conducted some experiments with various forms of batteries and while engaged in investigating the new exciting liquid which has come into the market lately under the name of conquonbite, I used a battery which is made in Philadelphia by Partz, called the Partz Acid Gravity Battery. It is a square cell in which the carbon is placed on the bottom. The carbon has a corrugated surface. He has one form in which there is simply a zinc, as in the gravity cell. In the other form, he has a porous cup with the zinc inside, and I have found that when the liquid was at the lowest specific resistance possible, the total resistance of the cell, carefully measured, was as low as 1–100 of an ohm, and consequently anybody might think that you might obtain a very large volume of current; but unfortunately as soon as you close the circuit you find that there is only a very small current, comparatively speaking. You may get between five and ten amperes, but even that not for a great length of time, simply because you have the counter-electromotive force of polarization which immediately reduces the available electromotive force. I am told they are using these batteries with great success for dental purposes. They generally run them in series of three or four, they do not ask such a great rate of current for them and depend upon greater electromotive force to get the greater number of watts necessary. The cell is certainly a very convenient one, so far as construction goes, because it is so made that it will run without care and comparatively very little attention for months. There is a tube, a sort of perforated device which opens at the top through the cover, and the solution formed from a chromic salt, can be put in, as occasion requires, and all that is necessary is to add the chromic salt occasionally, and the battery will last practically until the zinc is pretty nearly worn out, without changing the fluid at all, until the solution becomes so charged with zinc that it is no longer expedient to run it. You could take out some of the top part, charged with zinc and replace it with sulphuric acid and water. I have not made any experiments with the battery using that liquid, and consequently I cannot tell how long it will last; but it occurred to me that it was a very convenient form of cell, particularly for in-door use, office work and places where the battery is to be tried for a certain length of time and where it is desired to have a battery that does not require much looking after. I succeeded in getting four amperes out of a conquonbite solution and I was led to reason from this that possibly the regular Partz solution would give a higher current; I think that I was told recently that Mr. Partz himself was using them a great deal for motors where the current was two to ten amperes continuously.

MR. CURTIS:—Dr. Partz tried it in my office and it would not maintain more than three.

MR. MAILLOUX:—That was because the porous cup has a higher internal resistance than the gravity.

MR. CURTIS:—This was a gravity bi-chromate battery. He used his bi-chromate which is exactly the same as ours. In fact, we have an interference in the Patent Office. It was anticipated by a French publication away back. We saw Dr. Partz and found what his dates were. He filed his application. We told him what this anticipation was and he said he guessed he would file his application; and I rather think he must have suggested to the examiner that there was this anticipation, because all the applications were withdrawn and we were obliged to strike out the most important claim: so I do not think anybody will get the patent.

MR. HAMILTON:—The battery which I have experimented with has been very low indeed—not in any case much over half an ampere—and I am sure that would not do to work your motors where you require eight.

MR. MARTIN:—Our worthy friend, Mr. Mailloux, has lately been investigating—as he investigates everything—the subject of secondary batteries. This month he lectures before the Franklin Institute on that very important subject. Now this whole motor question resolves itself into a question of current. If once we have the motor, the question comes where shall we derive the current to drive it. It is very apparent I think, from this discussion, that the day of the primary battery in driving motors is not a very long one. Where shall we get the current then? We can get it largely from the arc circuits; we can get it from the incandescent circuits. There are 700 to 1000 motors on arc circuits and a great many on incandescent circuits. Mr. Sprague, for instance, has a large number of small motors in Boston—25 or 30—running on the Edison three wire system. But in order to put motors into residences and have them running when people want them, you ought to have a current that is available all day long in a great variety of places. In order to get that current, it seems to me we must in the last resort, fall back on the secondary battery. Mr. Mailloux being in possession of some very important data on that subject, I think he might oblige us.

THE CHAIRMAN:—My own company has been preparing for a long time to put down conductors for electric-lighting and for power and for every other purpose, but the trouble seems to be that this subject is loaded with the mighty incubus of the underground sub-way commission, and they sit upon it. They keep out the motors. They do nothing for the public, but everything for themselves.

I should be very glad, as the rest of us I have no doubt would be, to hear Mr. Mailloux on the possible application of secondary batteries to the running of small motors.

MR. MAILLOUX:—I do not think I shall be able this evening to make myself very interesting on any subject, and I have given so much time to the storage battery lately in my efforts to study it and to arrive at an understanding of it, that I made it a point not to talk shop outside of business hours, and it has become almost a shop matter with me. I think that the discussion of the motor itself is full enough of interest to take up the time of the whole meeting. There are very many features about small motors worthy of a great deal of attention; one is the efficiency of small motors. We have all been educated somewhat to look at the efficiency of a small motor as being necessarily low, but that is simply because we have not learned to dissociate the various factors of efficiency, We must first determine what we mean by efficiency—whether we shall indicate by that term the absolute efficiency of the machine, or merely its efficiency to convert mechanical energy into electrical energy or vice versa. The point I wish to emphasize particularly, is this, that while a motor may be very small and have a very small mechanical efficiency—a small co-efficient conversion—that is to say, its power to convert electrical energy into mechanical energy may be comparatively small when compared to a machine of much larger dimensions, yet the total efficiency may still remain at quite a respectable figure. When used as a generator it would convert a small proportion of energy of one kind into energy of another, but the total efficiency is not affected by that; it is the product of the electrical efficiency in the circuit, and the efficiency of the machine itself. Consequently if your motor efficiency is lower, then you have only to raise the electrical efficiency in order to have still a total efficiency which shall be equal in any case. In saying this, I have reference more particularly to tests made by various authorities, such as Ayrton and Perry, and Prof. Anthony and Lieut. Duncan, and others, in which they have shown very low total efficiency for small motors; I think in some cases as low as 13 per cent. of the total energy and in no case above 50 per cent. Now I have believed that they were not giving the motor a fair shake. The instrument from the necessary complications and limitation of its construction—it being of a small size, would be a very poor instrument to convert energy, so that its own co-efficient of conversion would be very low; (I use the words co-efficient of conversion, because I think it expresses the idea exactly); that is to say, the ratio of energy that this machine can transform. Yet, although its efficiency may be very low, the efficiency of the circuit is entirely independent, and that is the ratio of the total amount of work being done. It is a function of the total amount of work that is being done in any case. In any electrical circuit the efficiency of energy transmitted varies as the counter-electromotive force. It is a ratio of the counter-electromotive force to the total electromotive force. Let us suppose that this machine when used will transform 80 per cent. of the mechanical energy applied to it into electrical energy. Let us suppose, further, that 90 per cent. or 95 per cent. will be useful in the external circuit; so we have a total co-efficient of useful conversion of eighty times 95, which is 76 per cent. Now that is the co-efficient of conversion so far as useful effect is concerned. Now let us suppose that we have a battery so arranged that it will allow this motor to run at as high a speed as possible, and that we get the power out of it when it is running at 1,500 revolutions. Let us suppose that the current is as small as is consistent with getting the power.

Mr. Curtis:—Excuse me. It is the resistance of the motor that determines that thing.

Mr. Mailloux:—Not necessarily.

Mr. Curtis:—You are running your counter up just as near your direct as you can. Now it is that resistance that determines the amount of current.

Mr. Mailloux:—No; it is the total electromotive force you are using in the first place. If you are using a large total electromotive force, then your motor can give a higher electro-motive force, consequently it will develop a larger counter-electro-motive force, and the ratio of the two would be large. Now the total work that will be given to that motor may be anything you please. Let us take the case of the Edison circuit. This machine can be wound so as to give comparatively a high counter electro-motive force and we can make the ratio as high as we please and get the same power with a much lower current, and I find he uses current of about half of an ampere.

Mr. Curtis:—Eight-tenths.

Mr. Mailloux:—Eight-tenths of an ampere. Very well. Now this would show that the counter-electro-motive force of the instrument would be a higher ratio and we may easily see that you cannot get 90 per cent. electrical efficiency. In other words the amount of the electrical energy that is required to transform to the moving part in proportion to the amount that is absorbed in the moving part itself is the ratio of counter-electro-motive force. Therefore the electrical efficiency will be anything you please according to the speed with which the motor is run. Consequently the total efficiency will be 76 times 90, which is a little over 60 per cent. That is what I mean to say—that although this may have a very low conversion, yet by raising its electrical efficiency, we can raise the total efficiency.

Mr. Curtis:—What is called commercial efficiency is the same thing as what you mean, taking into account the external and internal resistance in the machine. Take an ordinary dynamo machine—it does not affect the converting power, whether it has a high internal resistance or low internal resistance. In regard to the amount of current that it is necessary to supply it with in order to obtain a given power, that element is of no importance at all; nobody cares what the internal resistance is. The only trouble about having high internal resistance is that it absorbes the power, and then it prevents self-regulation. There is a great deal of talk about commercial efficiency. The most important thing is just the converting power. If you put 100 volts and $\frac{3}{16}$ of an ampere on that wire, then put on the friction brake and take out the foot-pounds, the proportion of friction that goes out to the amperes that go in gives the important thing as regards efficiency. The other important thing is how many dollars of ampere it takes to give an eighth of a horse-power or a tenth of a horse-power or two horse-power, whatever you want.

Mr. Crocker:—There are two efficiencies, only, necessary to be considered. One is the theoretical or electrical efficiency; the other is the commercial or net efficiency. Now there is nothing ambiguous about any of those terms. The theoretical efficiency means what Mr. Mailloux calls the co-efficient of conversion; that is, its efficiency as an electrical instrument. That is its efficiency which is interesting to a physicist as being the efficiency of an electrical instrument. Then coming to the question which is interesting to the man who pays his electric-light bills—how much of that electricity that is produced by that instrument gets into his lamps? That is the commercial efficiency. In either case there may be any fraction less than 100 per cent. Take the case of a dynamo. We put into it 100 units of work—energy. Now that dynamo converts 90 units [I use round numbers to facilitate multiplication] into electricity, in that instrument or outside of it—anywhere. Now that dynamo delivers to the consumer 90 per cent. of that 90 per cent., which is 81 per cent. commercial efficiency or net efficiency. Now it seem to me that without much mathematics that thing is very simple. I do not see any use in considering in a general way anything but those two efficiencies. Their names are not ambiguous—the electrical efficiency or theoretical efficiency and the commercial efficiency or net efficiency.

Mr. Wetzler:—I rise to a point regarding efficiency, not theoretical, but in a practical sense. I would like to call attention to a fact in regard to the construction of the armature of a motor. I am acquainted with a very well-known electrician who has started out to make a small motor of large efficiency—one which should approach the efficiency of the larger motors. He started out with a solid armature of the Siemens type. He got, I believe, 15 or 20 per cent. He tried all sorts of winding, etc. It occured to him that it might be well to laminate that armature, which he did to a certain extent, and he obtained 10 to 20 per cent. more efficiency. He kept on increasing the number of laminations until he reached 60 per cent. Consequently I would like to point out that the efficiency of a small motor must be looked for to a considerable extent in the lamination of the armature. I see in the armature before me that the attempt has been made; but it strikes me that it could be improved upon—if the suggestion is allowable. It seems to me that there may be some chance of the current getting across these sections.

Mr. Curtis:—We made one test. We mounted one of those rings on a wooden block, without any winding on the armature and ran it at a high speed, and we found that whether you turned the field on and off or not—that is whether it was revolving in the magnetic field or not, made only a very small difference, and that was with an armature in which the lamniations were only half as thin as they are there.

Mr. Wetzler:—You had no windings on that at all.

Mt. Curtis:—No windings.

Mr. Wetzler:—You cannot say then that the conditions were exactly alike. Did you ever try a solid core with your actual windings on it? That would be a crucial test.

Mr. Curtis:—No; that would be so vastly different from a solid core. Until you get up to a certain point the efficiency runs up very rapidly. Beyond that point the Foucault currents are so small that it does not pay to carry them much further. We considered the thing very carefully and I do not believe that there is over five per cent. lost at the very outside by Foucault currents.

Mr. Wetzler:—You will also remember that some time ago Mr. Mordey pointed out distinctly that the loss from the motors was due to that very cause—the Foucault currents.

There is another point I want to bring up, and that is, don't you gentlemen consider it advisable to have some arrangement for reversing the motor? For many applications it is desirable that the motor should run in the opposite direction.

Mr. Wheeler:—Do you mean momentary reversal?

Mr. Wetzler:—To run a machine in either direction.

Mr. Wheeler:—You can do that; you can change the field connection for one thing.

Mr. Wetzler:—I mean having your motor on your lathe or work-table and being able to turn a switch or any other mechanism and having the motor run in the opposite direction.

Mr. Curtis:—We have not had any demand yet for such a machine, and the principal purpose that has occurred to us for that kind of thing is for use on a boat.

Mr. Wetzler:—I can see very well that there would be more than one application for that kind of motor. For instance, a dental lathe would require reversing.

Mr. Martin:—Dentists have asked me if I knew of a motor of that type.

Mr. Curtis:—One point about these brushes is that they are arranged so that the armature can be turned in either direction without destroying the brush.

Mr. Pendleton:—When I had the pleasure of meeting you here last month, the prominent subject of the evening seemed to be secondary batteries. With an experience probably second to but few in this country, in secondary batteries, I felt that the claims of 80 and 85 per cent. were so far beyond anything that I had realized, that, as a matter of courtesy, I avoided the subject entirely—that is, in speaking of the value of the accumulator. Now, the accumulator has great uses, in my opinion; but it will be wrong to claim any efficiency for it, of anything like 85 per cent. I would be perfectly satisfied to have a fair commercial—not theoretical—efficiency of 50 per cent., not that above 50 per cent. cannot be shown, because 60 and 65 per cent. can easily be shown by any expert. But where they are used roughly by uneducated help, 50 per cent. would be a good commercial yield. Now, with the electrical service from a central station, such as either the United States or the Edison circuits, any number of small motors could be regulated by means of a storage battery. The only matter to be provided against is the full charging of the storage battery in the circuit. Automatic devices to cut out and cut in and operate the motor from the storage battery are things that are already accomplished, though they have not yet been introduced. Some years ago I had a surgeon of this city make some experiments with an osteotome in my laboratory for the purpose of testing the power to be received from an accumulator, and for that purpose he brought down with him tibbæ feet bones, etc., and had his little saw attached to his surgical instrument which operated very satisfactorily; at least he said that he had never been able to get such results from any primary battery and he had spent several thousand dollars in trying to perfect a system suitable for his purposes. I noticed that his instrument got upon a dead point several times and I asked him how it was. He said it was the best he could find at the White Dental Manufacturing Company. I got a Griscom motor which is covered with an india-rubber shell on the outside and I furnished him with a motor which has attracted some little attention although it has never been put on the market to any extent. I have received letters from Paris in regard to the cut of it which was published in an electrical journal some years ago. That little motor fulfilled its purpose and it was simply the commutation of two brushes upon a three pole armature with the usual circuit, so that there was a continuous current through the two circuits of the armature and the polarities gave on the three-pole armature all the attraction and repulsion that was capable of being derived. I finally conceived that it would be a benefit to use discs of thin iron, and my experience in the matter fully coincides with the remarks made here to-night. There was a gain in efficiency of at least 25 per cent. merely from replacing the cast-iron with wrought-iron. In regard to the loss by Foucault currents mentioned here to-night, this ring, traveling in the periphery of the armature, would not suffer from Foucault currents as much as the ordinary armature which is placed directly upon the shaft and having the speed of the periphery so much higher than the iron near the shaft. In that respect I should hardly think that 65 per cent. would be an overestimate for that reason; whereas in the ordinary H armature, it would be very much greater. As to the matter of insulation, an insulation by peroxidizing this iron, might be quite sufficient.

These little motors are becoming very interesting and their importance will be appreciated as soon as we can get the current to introduce them generally, and when that time comes do not forget that the secondary battery will be a most valuable apparatus to regulate and govern those motors and economize at the same time the power which will be lost in any other methods of governing.

The Chairman:—It seems to me that this subject of street car traction by means of storage batteries is an important one. It may be, however, that the subject will be worth our consideration at the next meeting and perhaps some papers on the subject may be invited for a future occasion.

In regard to the core of this small motor and the oxidation of these plates—I suppose what he speaks of is the equivalent of the Bauer–Barff process, and before I heard of that process I got some of the black oxide of iron—the magnetic oxide—and I had it ground as fine as flour. Now, that is distinctly magnetic in itself; but it seems to me that to treat these plates in that way would not produce the desired result. I have suggested that where you have plates or wires in bundles, in a magnetic core, either an induction core or any other—that a simple process of light tinning would answer all the purposes of insulation in this core. Suppose these plates before they were put together were lightly tinned and then sweated together, the question is whether that would not prevent the Foucault currents.

Mr. Curtis:—The Foucault currents are produced as a result of the conductivity—it is an electric conductivity as far as we know. We cannot see how it can be anything else, because as soon as you have a low enough resistance across there for the currents to be conducted from one lamina to the other, there will be a current generated in the iron just as well as in the copper wire outside.

Mr. Wetzler:—I believe when Mr. Pendleton referred to the peroxidation of these plates he simply referred to the rusting of them. I have heard of a man who in order to decrease the effect of the Foucault currents, in building up an induction coil dipped his wires in acetic acid. By then bundling his wires he obtained a good insulation comparatively between the separate ones, and thus discharged the Foucault currents.

Mr. Pendleton:—I did not mean the rusting of the iron, although that is a good insulation. I am speaking of the black peroxide which is known to be as good an insulation as rust itself.

The Chairman:—You know in the experiments of House on the magnetization of iron, that that magnetization was found of different degrees, as the iron was laminated from the surface; and it occurs to me that there is more in the distribution of magnetism under the influence of an electric current through solid bodies and bodies that are divided up by a non-magnetic material than perhaps has been brought out and demonstrated practically. It has got to be beyond ten o'clock and perhaps it is time for us now to adjourn. I think we have all been interested in the discussion this evening and in the beautiful manner in which this motor has been exhibited and its efficiency demonstrated.

The meeting then adjourned.

DISTRIBUTION OF ELECTRICITY BY SECONDARY GENERATORS.

SPECIAL MEETING.

March 15th, 1887.

The special meeting for the consideration of the subject of distribution of electricity by secondary generators, was held at 130 Broadway, New York, at 8 p. m., March 15th, 1887, the President, Mr. Frank L. Pope, in the chair.

THE PRESIDENT:—Gentlemen of the Institute:—It affords me great pleasure to be able to meet with you once more. I had begun to think that I should not see you again for some time. I am glad to see so large an attendance.

The subject for discussion this evening is the "distribution of electricity by secondary generators." As you all know, the problem of the distribution of electricity for lighting, by induction apparatus, variously called secondary generators, transformers, converters, etc., is attracting a great deal of attention at the present time. It is not a particularly new thing, having been employed in one form or another pretty constantly since the early part of 1883, yet it is only quite recently that it has been brought into what may be properly termed a commercial condition.

Very many of you are doubtless aware, that something over a year ago I was commissioned by Mr. George Westinghouse, Jr. of Pittsburgh, now President of the Westinghouse Electric Company, to go to Europe and make an examination of this system, and if advisable to purchase some of the leading inventions for use in this country. Mr. Westinghouse had already made some experiments in that direction, and had become much interested in the future possibilities of the system. I went over to London in January, 1886, and had the pleasure of seeing there an installation of some twenty-five hundred lights working under the Gaulard and Gibbs patents, at that time the only important installation which had been made. I saw that there were great possibilities in the system, although it was not worked out in practice as we would work it out in this country, by any means; I was nevertheless so well satisfied with the results already attained, as well as of the possible results which we could get when we put our young men in this country at work on the details, that I closed the purchase of the Gaulard and Gibbs patents for Mr. Westinghouse. Up to that time the invention had not apparently attracted very much attention in this country; but during the past year a great deal of progress has been made and it certainly seems now to have a great future before it. Theoretically it is unquestionably a system of the utmost interest. There are many novel features embraced in it—novel in the sense that they have not been practically worked out and applied. The action of the induction coil is a great mystery to many people and is in fact not any too well understood by the best of us. My work in connection with the system has not been of a practical character, and in fact I have hardly an opportunity during the past year to examine any of the installations which have been put in.

Dr. Otto A. Moses:—What I have to say to-night on this subject of secondary distribution will not be of a very profound character, although from having seriously investigated the subject for sometime back, I might be inclined to treat it more precisely. I see, too, among the guests, one who I know would prefer to look at it from a thoroughly scientific standpoint. What I will say was suggested to me but an instant ago by the action of the incandescent lights which startled us by that sudden flicker. (Laughter). I would not have stood in the shoes of the man where that thing originated for something handsome. He must be in a profuse perspiration at the present moment. I think I see him tugging away at a brush, a long stream of fire issuing from it. There is a general gathering of the hive; and they are making every effort to stop it. They are loath to put their hands on the brushes, because any attempt to stop a sparking at the commutator may lead to further flickering of the lights. For that sparking is the weak point down there; and it seemed to come very opportunely for us just now to show one of the advantages in a secondary distribution.

In the secondary system, at present, electricity is distributed in alternating currents. Whatever violence there may be in changing the direction of a current of electricity, two hundred and fifty times a second, takes place in such a way as to be silent and invisible to us.

The production and distribution of alternating currents is so simple a matter that the very first dynamo machine ever made was constructed on that principle. I recollect when Comte du Moncel told me of the consternation with which the people who were interested in the Alliance machine, came to him one day and said, "The thing won't decompose water," for which purpose it was being made. "Well," he said, "I don't see any other way to do than to make it decompose water by turning it into a machine with currents of one direction; but if it were my affair I would leave it an alternating machine. Why not use the current at once for making light instead of decomposing water with it in order to get light from the recomposition of its elements?" It was a very unfortunate thing that the alternating current machine did not decompose water, because we would have been about twenty years further in advance in the application of electrical science. That was the quietus of the alternating current machine for the time being. Well, they made a continuous current machine that decomposed water; but soon they found they could make light a great deal cheaper by that alternating current machine than by combining hydrogen and oxygen. The first alternating current machine they made I have seen working near Havre, in the lighthouse. It has never been stopped but once, and that was in order to put in a pillow block. No accident has happened to it, and it has been going on beautifully ever since. It was put in 1862 or 1863, I think. But it was a cumbersome machine. However, it was as smooth running and as strong as anything possibly can be. Now, the alternating current machine is so simple that it is a wonder to me that it did not continue in general use. But then there came another matter to give it a set back. M. Archereau, (a very pleasant man and very much of an inventive crank), discovered that a solenoid was a very excellent means of regulating a lamp. You could not use the alternating current with that. Therefore the whole stream of invention ran into the channel of continuous current machines, and from that moment continuous current machines were universally studied, because they could operate the regulating device of the ordinary solenoid arc lamp; and as the arc lighting business was the great one by which electricity was going to be built up as the power for general use, practical continuous current machines were invented and generally adopted. Now, when a thing once gets on the ways, sliding down like a ten thousand ton ship, you cannot stop it.

It is bound to go, and when everybody's mind gets acting on a certain kind of improvement in a fundamental invention, it is bound to go on that route. Look at the Morse system. It is only quite recently that they began to take messages off by sound. No one would have thought of taking off messages by sound when I was a boy. Why? Because everybody did it by reading from the paper, and so everybody had to continue to do it. Such are the grooves in which the mind of man runs. The development of an invention is very much like forging a chain; one link has to be connected with the other until you get to the end of the chain. Then you may start another chain if you wish; it may be of different sized links and of different materials, but if you want to have that chain complete, its links must be of the same material and be pretty much of the same size. The invention of the Jablochkoff candle gave another stimulus to the alternating current machine; but popular prejudice, excited by the death of a careless sailor on a Russian royal yacht, caused its almost total abandonment for use in electric lighting; and finally the introduction of incandescent lightning on a great scale on continuous current circuits, made it disappear entirely from use.

But now the alternating current machine has taken a new and grand departure, because we find that you can only distribute currents by secondary generators where they are alternating in their character. Therefore, the alternating current machine has to be introduced, and its great advantages which were hidden, simply because they were not needed in the beginning, have come now to the front, and it will be adapted to all kinds of distribution of electrical power. That sounds like a pretty broad statement when we know that motors are being run on continuous current circuits. But what is the difficulty if you have got an alternating current machine that sends its currents to and fro? Why, usually you send it to and fro through the same point. You can send it *to* there, and you can send it *fro* here, and you can have all the continuous current you please on the one side, and all the continuous current you please on the other side. (Applause.) So that an alternating current machine can be made a continuous current one, and you can adapt the alternating current machine to any of the uses to which a continuous current machine is now applied.

Now, to come to the point, I would say that the practical application of this thing has been demonstrated to my satisfaction, and that is something that means to me a good deal. I think that alternating currents from secondary generators are going to drive all the small electric appliances for the distribution of power that are now used. Secondary generation is bringing about a change that is going to result finally in a commercial revolution. We will find currents distributed abroad in every direction, in every house, and we will have power at command for all purposes, just as we have it here at this moment in the incandescent lights around, and that is all going to come about through this alternating distribution.

I was in Pittsburgh the other day and saw such a system working, and it was very gratifying to one who has been through a good many of the mills of experiment. I had seen the first work done in incandescent lighting, and I know what the difficulties were and how long it took to overcome them all, except the one insurmountable difficulty to the distribution of that light by continuous currents over great areas; for the rapid increase in the size and weight of the conductors are a bar to the extension of a system of distribution beyond a narrow limit, where large quantities of current of low potential are to be consumed.

There is in Milan, Italy, a very large system of distribution of electric light, supplying some six or seven thousand incandescent lamps of this kind, from a central station. One of the owners and originators of that plant was Professor Colombe. You may have met that able gentleman when he was over here. He came to study the distribution in the city of New York, and he was so well pleased with it that he went back to Milan and started a successful central station there. He was subsequently appointed a Commissioner of the Turin Electrical Exhibition, when he was called upon to make an investigation of this very Gaulard and Gibbs matter; and although he was deeply interested in the central station there—the Edison central station—he in a published paper admitted that the method of distribution of currents of 100 volts potential was limited to an area of from 500 to 600 metres radius. Well, that figure in a distribution in a great city amounts to limiting it to an improbable point. All the influences in Paris so far brought to bear have not caused a central station to be established within the walls of that city, which would show that French capitalists believe that continuous currents with an electromotive force of 100 volts and thereabouts can only be profitably used for distributing power for lighting purposes within very small areas. Professor Colombe went further—although it was really against his own interest to say so; but, as one of the Commissioners of the Exposition, he said that the Gaulard and Gibbs method of secondary generation was going to solve the question of the bringing of power to and distributing it in a city. That is to say, in order to solve the question of electrical distribution you have to combine the bringing of alternating currents to local central stations and distribute them thence at lower potentials. He did not say anything about how you were going to transform the currents from alternating to continuous ones. He did not say it was desirable to do it; but he said it was a very necessary thing to bring in currents of high potential and to transform them into currents similar to those he had introduced into use in Milan. That statement came from a man whose entire interests were in other directions. Now, that is a very good way, by the bye, to judge of the value of an opinion. I have heard it once said by a lawyer (who was subsequently made a judge) that the true way to ascertain a man's merit is to see what his enemies give him credit for, because that he must have. Now, in his particular case, the merit of the Gaulard and Gibbs matter has been fully recognized by Professor Colombe (one of the best authorities in Europe) as the thing that is going to bring the current from outside a city to points within it of low potential distribution. I go a step further and say I do not see why it may not get there and then distribute itself, changing itself without the intermediation of a machine at the door of the consumer, into perfectly safe currents, as is done by the Westinghouse system of electric distribution. But, gentlemen, we must not delay any longer hearing what Captain Michaelis has to say. [Applause.]

CAPTAIN MICHAELIS:—I have very little to say. It happens that I am living at a place where some few friends of mine conceived the idea of starting an installation, and because they thought I knew something about guns and equipments, consequently I must know something about electricity; they spoke to me about it, and I thought it was time that I tried to learn something about it myself. You know that Marryatt has written a book called "Japhet in search of his Father," and I might write a book called "Michaelis in search of an Electric Light;" I think it might be worth reading. I have a great many friends in the Institute, all very nice gentlemen, and so I thought I would see my friends first. They treated me very kindly; took me to the Astor House, Delmonico's, Cable's, etc., and I began to get bewildered. All the lights were good and I did not know what to advise.

In the course of my wanderings, I struck a little hill town, pretty nearly a thousand miles from here, with not quite 5,000 inhabitants. I was provided with half a dozen letters to the electricians of the place. I arrived there one Sunday afternoon. Unfortunately the gentlemen to whom I had letters were absent. I hobnobbed with one of the men of the town whom I met at the hotel. We were searching for the same thing. It was not an electric light, however, in this case. (Laughter.) We became acquainted and I found that he was one of the stockholders in the electric light company of the place. He took me to his store and opened it, and I spent a couple of hours with him and I obtained a good deal of information that I thought would be of interest to my friend who had spoken to me, and I think it has proved so. Now, this little town is way up in the hills. It has less than five thousand inhabitants; there is not a single prevailing industry in the place. It is a little country town. I arrived there Sunday afternoon at four o'clock and the first thing that struck me was that the town was peculiarly lighted up. It was the first experience I had of this peculiar illumination. It was natural gas. I asked my friend what he paid for this light. He said fifty cents a month. I concluded electricity could not compete with that. I asked him if they had any gas there. He said that they had a gas company that had been charging three dollars a thousand, but they had put it down to $1.90 since this new light had come in. I asked, what have you got in the way of electricity? He then showed me the electric lighting system. He took me to their plant and I was much struck by it. It was a business looking place. There was nothing that was not needed and everything that was required was in its proper place. I asked: What did this cost you? He told me they had formed a lighting company with a capital of $15,000. They had a 600 or 650 light plant. They had purchased the ground on which the building stood and had paid all their expenses and had just about exhausted their capital. It was a sort of co-partnership; all the lights were subscribed for. The large room at the hotel where we met originally, which I suppose was perhaps 40 x 40, was well lighted with six 16 candle power lamps. I went to other places and was delighted with the illumination. One subscriber might say, "I do not use this light so much as another," and they would charge him so much less. I calculated that the average commercial light was sold for $8 per year. That gave them an income of $5,000. I footed up the cost of their services and expenses and I found it to amount to about $2,000 a year. I must say however that the coal was very cheap. They were only paying four cents a bushel for it. Now, this gentleman not being an electrician, I must confess, that you cannot rely upon his figures; but they had made, according to his figures, about twenty per cent. on their capital. Now, I do not wish to advertise any company, I do not even like to say where this place is, but I think, Mr. President, that this is a matter which is encouraging to all electric light companies. Perhaps it was a fortunate accident for this special company that it had its plant there. Still, in answer to inquiries I hear, I have no objection to telling you that the town was the city of Greensburgh in the mountains of Pennsylvania, and that the company that put in the plant was the Westinghouse Electric Light Company of Pittsburgh. (Applause.)

PROFESSOR ELIHU THOMSON:—Mr. President and Gentlemen: This is the first opportunity I have had of meeting the members of the Institute, and I am very glad that I came down. On former occasions I have been entirely too busy and pre-engaged to make it convenient to leave the place where we carry on most of our operations.

The subject for discussion this evening is one of very great and growing importance. I am forced to recall a little experiment I made, in illustration of the reversibility of an induction coil, before the Franklin Institute of Philadelphia, in 1877. I then gave a course of lectures on electricity; and the main principle put forth was that electricity of all kinds and characters—statical, dynamical or whatever you choose to name it, was really the same thing and of exactly the same nature, differing only in potential, pressure or electro-motive force and volume. I exhibited, of course, in illustration of this, Rhumkorff's coil; and while preparing the lecture it struck me that it would be a pretty experiment if I could reverse the process, and instead of getting discharges which would have the statical properties, I should take my Leyden jars and put the Leyden jar discharge through the fine wire of the Rhumkorff coil and see what I would get in the primary circuit. This I did, and I was somewhat astonished at the volume of current which seemed to come out of the primary. I expected, of course, to get a heavy current. I knew perfectly well that the

Rhumkorff coil must be reversible, but I was surprised to see the energy that the Leyden jar discharge displayed when it was turned into what was then called the quantity current; the ends of the primary wire being brought together, there was a bright green flash, and after repeating the experiment once or twice the wires actually stuck firmly together. It was with difficulty that I separated them. They bent a little, and with a good pull they separated. There was a sufficient proof of the reversibility of the induction coil. The capacity of the Leyden jars was three gallons. The spark which fused the coil was an inch and a quarter long. Another fact came out in the experiment which was very striking. We are all familiar with the loud snap produced by the Leyden jar discharge and the bright flash. I was surprised to see, however, that the spark which struck through the coil was exactly like the Rhumkorff spark. It occupied a time. It didn't go with that sudden energy with which the Leyden jar discharged, but it went through with the appearance of the ordinary Rhumkorff spark. This thinning out was no doubt due to the retardation which occurred in that discharge. That is, a portion of the current started out first—for we must in that case call the Leyden jar discharge a current, even though it may last a billionth of a second. It passed through, as I say, in the character of a Rhumkorff spark, and the primary current seemed also to last for the same length of time. This experiment was repeated and the primary wire was also connected with a galvanometer of very coarse wire and the needle went right up solidly to the stop at every Leyden jar discharge. At that time I thought it must be perfectly well known to anybody who would dwell upon the conditions.

This experiment left its impression on my mind; and my recent experiments in welding by electricity are really the outgrowth, as I see it, of that little experiment of the Leyden jar discharge sent through the Rhumkorff coil.

When engaged in electric lighting, I found it necessary, in the construction of dynamos, to make good joints on wire and it was with some difficulty that really good joints were made. Our wire in the early days was only obtainable in about fifty pound lengths of copper—and some of our coils required about 300 pounds—so that we had to make some five to six joints in every coil. This necessitated, of course, great care on the part of the man making the joints and he was oftentimes liable to make slips which would not even allow the wire to be bent to and fro. In thinking the matter over, it struck me that electricity would do that work, but the thing was to get the currents. They were necessarily enormous. They were necessarily much larger than we had been accustomed to deal with. Arc light currents and incandescent currents in those days probably did not in any case give more than two or three hundred or four or five hundred amperes. The machinery had not been developed to an extent beyond that. The induction coil experiment, however, seemed to point out the way, and I designed at that time an apparatus which I thought would answer the purpose, but I was compelled to lay the affair away and had no time to develop it further. Taking it up finally, however, I tried the experiment of building a small alternating machine and putting on it a moderately fine wire, which was to be the primary, and taking a very coarse and heavy secondary, so that the potential of the currents generated in the secondary might not exceed one or two volts at the most, but could run up to thousands of amperes. The first experiments made with the apparatus were entirely successful in joining copper, iron, steel, etc., the wires being a moderate size of course. I mention these facts simply to show their connection with the subject under discussion. We have there probably the extremest case of what we call conversion from high potential to low potential. Dr. Moses has mentioned the fact that no commutators are needed on the alternator; and I can say that it was really fortunate for us in welding operations that there are none, because our currents are varied enormously in a very short time. We start out with a piece of metal that probably has only a few square mils in section and the same apparatus we run up to an inch or more in diameter, and if we had a commutator on the machine that amounted to anything, we of course would have to make a new adjustment each time, and every time the current changed greatly it would be very likely to tear out the metal and throw it around, because we run under strong conditions while we are putting on the heaviest gushes of current.

As to the distribution of incandescent lights by the induction coil, I may say that, in the latter part of 1878 and 1879, in company with Professor Houston, I made some experiments with the design of using a little arc lamp for distributions. It is called a vibration lamp. The electrodes were vibrated to and from each other and we used induction coils to give the impulses to vibrate the carbons and also to supply the current to the little lamps. The incandescent lamp in those days was unknown. There was no such thing as incandescent lamps in 1878, at the time the experiment was made, but gradually the incandescent lamps became known, and the induction again began to attract some notice in regard to use in distribution. Now it always has appeared to me that there never could be any doubt as to the efficiency of a good induction coil; that is, that the losses in an induction coil never could amount to a great deal, if it were properly made. What is a dynamo machine but an induction coil after all? It is a revolving induction coil. We have what might be called the primary circuit in the field magnets, in the magnetism; but instead of reversing the current in the field magnets we reverse the position of the secondary, that is we turn it over to get our impulse, not that those impulses came out as gushes of current or waves; but if we turn over portions of the armature by degrees, we get a continuous even flow of current, and if the dynamo can be made to reach an efficiency of 90 per cent., why cannot an induction coil be made to go to an efficiency of 95 per cent? [Applause.] We use a reversed primary. We do not reverse the position of our armature in relation to the magnetic field developed by the field magnets; but we make our field magnets reverse and divide them up by laminations or by making them of fine iron wire; put plenty of iron in the coil and the losses should not be any more in making the conversion, so far as Foucault currents or local currents in the iron are concerned, then they are in a well constructed, laminated armature.

In regard to the use of alternating currents, let use see if there is any possible objection to the use of them. There has been a great prejudice against alternating currents, (which I think has gradually been removed) on account of the very fact that they alternate and that they are not without the danger of severe shocks. We have learned to look upon alternating currents, somehow, with considerable dread on account of the fact that the current goes this way and that. I had some early experience in that respect. Most of you probably have heard of the Jablochkoff kaolin light, in which the induction coil was used to throw discharges over a piece of kaolin, only the discharges were of high potential, produced by low potential currents. The electrodes were drawn over the kaolin and a very pretty light, of a moderate intensity was produced. It was in experimenting on this subject that I managed to get hold of the ends of the induction coil. To say that I was surprised would not express the conditions at all. Professor Houston, who was present, said that I jumped into the air about three feet, and in doing so I broke away from the wires, but for a moment I felt that if the thing continued a few seconds there would be no more of me. I did not feel it anywhere but in my head, and it seemed as if a thousand cork-screws had beeen sent in from all sides to mix up matters internally. However, the wires were not very strong and I broke away very easily. The shock was probably severe, but the potential was such that the discharge could jump through three-eighths of an inch of clear air and the wire of the induction coil was not so very fine, but that considerable current could flow. The potential was enormous. Now, the other day in experimenting with alternating currents in which the maximum difference of potential existing was about 1,300 volts, capable of equalling in potential a good circuit of arc lamps, I happened to touch a post and bring my hand to another post, and I felt something or other queer and drew away. The result was, I got a little blister on the hand, but that was all. If I had short circuited an arc current of the same power I would not have got away so easily. I should have come away with my hand very badly burned. But as it was, the alternating current spark did not follow up as I ruptured the contact. That is a feature of the alternating currents which is very useful in rendering them safe. Let us see if we can find any reason for it. The alternating currents rise and they come down to zero, and they reverse and so on; but there is a line along the middle of the curve which is neutral. Now, unless the materials are of very high volatility, the spark formed is very apt to be extinguished on that reversing point. At the same time there is another fact which would cause that arc to be extinguished, and it is that the effects of self-induction or extra currents in prolonging the discharge are nothing. Take an alternating current, and in its changes it cannot follow up anything that has short circuited the apparatus. It would seem from these experiences that we need not have any great fear of the danger arising from alternating currents.

It is very doubtful indeed whether the fluctuations in the arc light current are not quite as great and whether the injury to a person short-circuiting an arc light current is not due as much to abrupt changes in the current as to the mere current itself. That is, an arc light current does not usually have the character of an even wave—a smooth wave. There are segments in the commutator acting just like so many break-pieces and whatever effect they produce is produced in an inconceivably short space of time; and if we could map the waves of a current they would be found very irregular and ragged. No doubt every one has tried the effect of a shock from a magneto-electric machine. Everyone knows that if the speed is regular and the contacts are good he can stand a pretty fair shock; but let it be irregular, let some faulty condition occur and give him a shock, and then ease up a little and give him some more and it will be found to be very exhausting indeed. In the one case he knows what to expect and is prepared for it; in the other he is not. This brings us up to the consideration of the nature of the alternating current itself. It is a ryhthmic wave, and it can be made so perfect and so smooth that at any portion of the wave the change of current is quite slight. There is not a sudden jump of current or a sudden action which though it occupy only the ten thousandth part of a second will make a considerable difference in the wave. Let us see whether we have any facts which would lead us to think that there is a difference of that kind between the ordinary arc light and the alternating current. In working on this alternating current matter, it occurred to us that there might be some difficulty in running lines on account of telephone interference. Injunctions might be served on anybody running lines, if the alternating currents had a bad effect on the telephone lines. To test that matter we ran parallel telephone lines to an alternating circuit, and to the arc light circuit using about the same current on each, and I was surprised at the results. The alternating current line did not give us any induction in the telephone while we had about fifty feet or more parallel and the arc light current gave us a strong induction—a rattling, scraping sound; and when I thought of it, it all came very clearly. At every segment of the commutator, there was a little break, just as quick as it could be made. A difference was produced in the telephone circuit so sudden that it was bound to produce a wave that would shake the diaphragm,—a kind of scratching, irregular sound, nothing melodious about it. Then we arranged the conditions so that we could get induction from the alternating current alone to the telephone line by increasing the length and coiling the wire a little and gradually we could hear the hum of the alternator; but it was music compared to the other. It was a musical tone; you could talk through it and not be bothered by it in the least. It is doubtful, as one of our men suggested, whether we could not, in case we had difficulty, play a tune; that is, we could send chords over the line by sending impulses the right way, so as to make everybody happy. I do not say that all alternating currents are of that character; but I do think that there is no difficulty whatever in constructing machines which will give waves that are very easy, regular, and just as perfect as you could have the waves produced by a fine tuning-fork, without any of the abrupt changes. Now I have no doubt that in the construction of alternating current machines, in which there are irregular changes in the magnetic circuits quickly effected, that the impulses would be harsh and rough. But if these changes are smooth and gradual, there is no reason why the sound produced in telephones by induction should not be very smooth and melodious, rather than disagreeable. [Applause.]

THE PRESIDENT:—I am sure we have all listened with a great deal of pleasure and derived no small share of profit from the remarks of Professor Thomson, and although not wholly in the line of the subject announced for the evening, we are more than pleased to hear from him something about the origin of his discovery of the process of welding of metals by electricity. I happened to be in London at the time the discovery was announced. A cable dispatch of ten or fifteen words was published which created a genuine sensation among the electrical and metal people; and although by this time some of them have doubtless discovered that it is not true, and others that everybody knew it before, I heard very little of that sort of talk at the time.

Professor Thomson has called attention to the resemblances between the induction coil and the dynamo. These resemblances which he has illustrated so beautifully, need to be better understood than they are. The induction coil, as he has shown us, is nothing in the world but a stationary dynamo, in which the poles are moved within the mass of the iron instead of the iron being moved bodily. Hence it is very plain, as he says, that we ought to get a higher percentage of efficiency from a properly constructed induction coil than from the most perfectly constructed dynamo; because the mechanical difficulties that we meet with in providing for the rotation of the armature are eliminated. We can bring the parts into closer relation with each other, and in that way we necessarily increase the efficiency.

In regard to the remark which Professor Thomson made respecting interference with the telephone. I was told in London that a circuit was originally run there some six miles in length, (the primary circuit of the Gaulard and Gibbs system) a rectangular loop embracing eight or ten blocks, and that the commotion which was created in the telephone exchanges by induction from the alternating current was something frightful. Injunctions were applied for, and there was a great controversy. Finally, after some discussion the circuit was arranged in the form of a double loop; that is the loop was formed into a sort of crescent, the wire out and back being carried on the same supports all the way. That immediately removed the disturbance; you can scarcely hear the slightest trace of it in the telephone now, although the lines go through the same neighborhood. The fact is that the currents of the circuit out and home seem to neutralize each other, or at any rate they are effectually neutralized. The induction does not get into the telephones. I would like to hear whether Mr. Wetzler has anything to say about this.

MR. WETZLER:—I do not know that I can enlighten you very much on this subject, but it strikes me that the point of utilizing a high potential current of low quantity for the purpose of facilitating distribution is one which can be looked upon in another light; that is to say, we may use a continuous current and interrupt it. The arc current to-day may be considered in that light. We have there the conditions of a high potential circuit with low quantity. Why may we not by suitable apparatus break that current at certain points, utilize it to put our secondary generators in operation and then continue it on; or, if you will, break it directly at a central station and use the broken continuous current (if you might so call it) in the same way as you would the alternating current? That system has been brought out recently and I think it presents some considerations worthy of notice.

We have all heard of the advantages and also of some disadvantages of the secondary generator system in this country as presented here. I think it may interest the members to hear the opinions of some foreign electricians on this subject. Dr. Moses has given us Professor Colombe's opinion, which is very favorable; and I think, for the sake of discussion, that some of the unfavorable opinions might be brought forward. In a pamphlet recently issued by Messrs. Siemens of Berlin, they flatly contradict the utility of the secondary generator system. They say in effect, that isolated installations, even large ones, are practicable on this system, as witness some of the installations already existing in Europe. These they consider, however, only isolated systems, though on a large scale. For a general distribution they claim that the thing is not feasible, in fact is not as good as the ordinary two-wire direct distribution. I must say this, however, that they premise that all distribution must be done by underground conductors. They say that if you want to distribute generally, an overhead system will not accomplish the result; that there are too many uncertainties in connection with it and that you must go underground. Now they figure up that to put underground a high potential system, in which instead of using 100 volts ordinarily, you use two thousand volts, with a corresponding reduction in copper; the money you save and interest on that copper will not make a difference of one per cent. in your running expenses. They say that the copper in the conductors underground is but a very small item in their expenses; that the insulation on the conductors costs a great deal more and is almost equal to the cost of copper, no matter what the size of your conductor is, and that what you gain in conductor you will loose in insulator. Then, of course, they bring out the usual argument against the alternating current not being available for motors, which they consider an adjunct for electrical distribution. Now, how far these objections are good, or how far they can be removed remains to be seen. I think they can be removed; if they are not removed already. But such is the opinion of Siemens, which has some weight, whatever his motives may be. He also says that you cannot regulate your secondary generator within the limits; that it must be regulated to give satisfactory incandescent lighting. He says if a secondary generator will regulate within four per cent. when turning on all the light, that that is not sufficient, and that secondary generators cannot regulate closer than four per cent. I believe that that objection can be removed if it exists.

The President:—I would say in respect to one point raised by Mr. Siemens that it is not quite clear to me, since a secondary generator is nothing more than a dynamo—why it is not possible to regulate with such a generator as it is with a direct distribution.

Mr. Wetzler:—Siemens in his pamphlet criticises other systems; but he says that he has got something that will regulate it.

Mr. Mailloux:—There is one point in Professor Thomson's remarks, which interested me very much and I see that our worthy president has also referred to it; that is the analogy between the dynamo electric machine and the induction coil. In the discussions upon the subject of the secondary transformers before the Electrical Society at the last meeting, I dwelt rather at length on that very question; and just here I must say that I must differ somewhat in the manner in which I viewed the subject. It is undoubtedly true that ideally considered the dynamo electric machine is an instrument for producing alternating currents; that we only reverse them by means of a commutator; but it is not a transformer in the sense that it gives us energy of the same class as the energy we put into it. In the dynamo electric machine we employ mechanical energy and it gives us back electrical energy. At the electrical exhibition in 1884, I remember seeing something that greatly interested me, and that was an apparatus designed by Professor Thomson. It was a dynamo electric machine, in which there were two armatures; the inner had four cores and one of the armatures was wound with wire capable of standing the arc light current, it also having a commutator. The other armature had small collectors. There we have what I call a first class analogue of the induction coil; because we take electric energy of high potential and we transform it into electrical energy of low potential, so that the other analogy brought out by Professor Thomson is only true in the sense that all forms of energy are from the same source and that we transform mechanical energy which is of comparatively low potential into electrical energy of high potential, because energy of high potential as distinguished from energy of low potential merely means this, that in energy of low potential we have a small weight carried over a larger distance; whereas in energy of high potential, we have a large weight (or what is equivalent to it—a large pressure) doing work through a very small distance; so if we consider the energy of electricity due to the molecular action taking place in the wire, we can see that we have enormous pressures acting on very small masses. Now, if we revert to the analogy just stated we will readily see that we are taking energy of one potential from the arc light circuit and transforming it into energy of a lower potential, but of greater volume, and in each case the amount of energy converted can be estimated by the ratio of the electromotive forces. Professor Thomson states that the efficiency of an electrical dynamo machine being as high as 90 per cent. there is no reason why we should not have a higher efficiency even in the induction coils. Now that is true and I must permit myself here to point out one reason why, and that is this: in the secondary coil of the transformer we have practically no dead wires. That is an important distinction in all forms of dynamo. There is always some wire which is dead by reason of the fact that it is placed at the ends of the armature, or inside of it where it is not subjected to the action of lines of force. In an induction coil on the contrary every particle of the wire is placed in a magnetic field, and necessarily we must have a greater efficiency of transformation. In the dynamo machine we have now arrived at the point where we can tell pretty nearly the length of wire that will be necessary for one volt when the field is at its normal degree of saturation. I would like to know if any gentleman present has had experience enough to tell us whether he does not find that in an induction coil the same mean electromotive force will be obtained with shorter length of wire, the general conditions such as magnetic density, velocity of relative motion between lines of force and wire being of course taken alike.

With regard to the action of the telephone, I must say that the statements made by Professor Thomson brought to recollection some very interesting facts which have been in my mind for a long time. Last summer I was engaged in the investigation of some matters connected with the telephone, and I had occasion to look into the theory of telephonic action in general; I remember particularly going over the researches and experiments made by Mr. Van Rysselberghe in Europe, and there I found that he endeavors to prevent induction in telephonic lines by taking electric impulses and subjecting them to a process by which they become undulatory; he gives them that rhythm which Professor Thomson alludes to, and when he has done so, he finds that they become powerless to produce induction on telephone lines. The facts are well known, and to-day in Europe the Van Rysselberghe system is very extensively used over telegraph wires, and the impulses of telegraphy, which are sharp and abrupt, are so reduced by introducing condensers and self-induction coils that they assume this harmonic form, so that they become no longer capable of producing any effect on the telephone, and the telephonic impulse can be superposed over them to reproduce articulate speech.

There is one important fact in regard to systems of transformation that has not been alluded to this evening, namely, the static effects which are produced by the passage of the current in the conductors. If we consider a transformer, we see at once that it is composed of a conductor and a dielectric. If we consider the secondary as merely a certain amount of surface with the circuit open, we have in effect two large surfaces brought into comparatively close opposition to each other, but separated by a dielectric which is the insulating substance, remembering the fact, that the charge of a condenser is a product of the electromotive force into the static capacity; it seems quite plain that even a very small static capacity would be able to give rise to very large static charges. It is true that we reverse the impulses of the dynamo and that the reversals take place so quickly that the process of charging, which requires a certain amount of time, will not have time to take place fully. I know that at the time when the subject was first discussed in Europe, there was some apprehension regarding the static effects to be anticipated, and I have heard that in some installations, I do not know whether in this country or in Europe, it had been found in practice that static sparks could be drawn from transformers. Now, here is a state of things which certainly demands investigation, and if it should prove to be at all an evil, certainly a remedy must be provided for it. I understand that Professor Thomson himself has anticipated this problem, has probably come across it and has suggested remedies or means by which it might be remedied, and as we have all, no doubt, greatly benefited from what he has said, I think that we would be very much pleased to be enlightened further on this subject and also on some of the other topics which I have no doubt he understands fully.

Professor Thomson:—I will say in regard to the efficiency of the wire of an induction coil that it is certainly possible to produce a higher electromotive force in a wire subject to induction than it is possible to produce in a dynamo armature. The reason however, may not be the same. It is practically a greater speed that does the work; that is, the alternations may be made at various rates; we can have 10,000 alternations per minute or we can have 15,000 or 20,000, and it would naturally result that if the field of the induction coil should be changed 20,000 times and to the same degree, that at that rate of alternation the wire should give out in the secondary (at least a certain length of wire should give out) twice the electro-motive force that it does when subjected to 10,000 and also that the primary wire should kick back, as we may term it, with a double kick, or in other words be able to hold back an electromotive force twice as great.

The question arises: Is the secondary wire *S* (fig. 1) in the magnetic field? It is not; that is a certain fact. The magnetic field is around it and does not show any polarity whatever and the secondary wire is not in the field; but the secondary wire was in the field at the moment when the magnetization was going on. Consequently the secondary wire gives out a current when the primary wire is beginning to take the current up to the maximum which it may reach. To make that plain, we will separate the wires a little. We will call each a single wire.

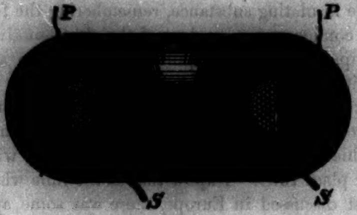

Figure 1.

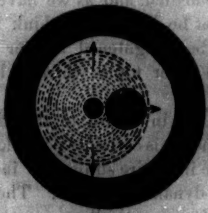

Figure 2.

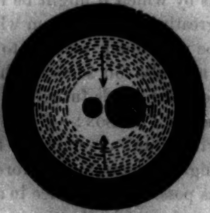

Figure 2 A.

That will be the primary *P* (fig. 2); this the secondary *S*. Now, what will be the effect if we pass a current through the wire *P*? It will cause circular magnetism around itself, and that circular magnetism will emanate in all directions quickly, and stop only when it reaches the best medium, that is, when it gets into the iron. That is my view of the action. I do not know that such view has been adopted by others at all, but I look at it in this way, that the wire conveying a current gives out as it were shells of magnetism, rapidly expanding to large dimensions. But if they meet with such a good atmosphere as iron, they condense themselves in the iron. What does the secondary do? If it has an open circuit it does nothing. If it has a closed circuit it develops a current. I say when it has an open circuit it does nothing. I am not strictly correct there. It develops only an electromotive force in the two ends of the secondary, which, if there is a circuit to produce a current over, will produce that current. But the very fact of the passage of the current in the secondary tends to produce just the opposite magnetization; (fig. 2 *A*) that is, as the primary lines pass across, the secondary would oppose them by producing a field of its own. But if the primary current is much the stronger, then the secondary has no chance to have a field of its own and it kicks all the harder for that reason; that is, it gives out more electromotive force or current just because it cannot have its own way.

As to the actual practice in regard to the length of wire, let us, before stating what I know to be the case in regard to such action, see what we have in the alternating current. We have an increasing current from zero up to maximum (fig. 3.)

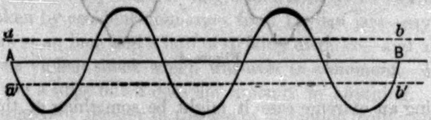

Figure 3.

And following the current down to the zero, and oppositely following it up to a similar maximum and so on through, what volts shall we say such current has? Shall it be measured by the distance between the top and bottom of the wave, or the average of positions on the wave, *a* to *a'*. Now, it is evident that in running an incandescent lamp the maximum electromotive force is not used. When you put a 75-volt lamp on such a current, you do not take that; the maximum must be higher than 75 volts, because the electromotive force does not last all the time. The maximum differences of electromotive force are probably nearer 150 volts, and we have a point near the zero line where there is not any difference. We must then take the average and that is the average volts. You see that this gives us another view of the electromotive force developed in the coil. If we count the maximum difference, then this wire is developing more than it appears to develop per foot or per number of feet. Now, in actual experiments with alternations of very nearly 10,000, the volts generated in such a coil per foot will be away down. I should correct that expression, the number of inches to develop a volt by such an arrangement will be somewhere between six and twelve in the primary and secondary. But the singular part of it is, suppose we take as a figure nine inches, with rather slow alternations—I take rather slow alternations—but nine inches develops a volt in either primary or secondary coil. What does that mean? Why, it means that four and a half inches nearly develops a volt of maximum difference; that is taking the E. M. F. from a point at the highest point in the wave to the opposite highest point, it is a good deal higher than the average. I cannot say just now that the relation would be exactly one or two; because that would depend upon the shape of the wave. For instance, this wave might have such a form: (Figure 4.)

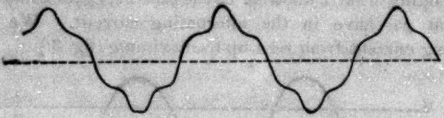

Figure 4.

Taking an extreme case it might be something of this kind: (Figure 5.)

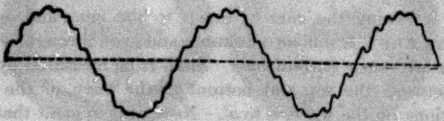

Figure 5.

And it might be an irregular wave and the average of the electromotive force in that case would be lower than in the regular wave. The point in regard to induction in telephones is also made clear by studying a moment the action which occurs in fig. 3. From any point to another lies a certain change in the phase and so all along. The changes are quite gradual, and if the diaphragm of the receiving instrument gets an induction which is so gradual that its motion is something like a slow impulse; it will not give a blow on the air hard enough to be heard distinctly; but if that wave should be of the character of this (fig. 5), then every one of these little jumps will cause the diaphragm to hit the air a blow which would be heard at the drum of the ear.

In relation to the static charge, I do not attach so much importance to it as would at first seem to be attachable to it, for the reason that the actual amount of condensing surface in the induction coil is not a very great amount after all. It is quite possible to take rapidly alternating discharges from a little magneto electric machine which may represent far more current energy than the charge or discharge of a moderate sized induction coil; although it is possible that with induction coils working hundreds of lights there might be a stinging shock obtained by touching the wire of the induction coil. The static charge, however, does certainly exist, but it represents very little current so that a person may take it without any trouble. A person standing on an insulated stool can have 10 inch sparks drawn from him and he does not mind it at all. He can charge his body through the potential of many thousands of volts and he can discharge that potential from his knuckles without any other feeling than a little shock in the arm. I have taken by accident discharges from Leyden jars—say three gallon jars at an inch and a half of striking distance—and all that I felt was a violent shock which was over in a moment. It may benumb you a little but it does not amount to anything. As to another source of danger in the use of induction coils; such an accident as this may happen at any time—by moisture or by faulty construction or some other such cause—the primary may become connected with the secondary or be so close to it as to cause a leak from one to the other. No particular danger should result from that alone although there would be a more vigorous discharge, statical in character, from such a connected secondary, because on the one side of the leak you would have a rather long line and at this one point you would be able to get the discharge of your whole line in rapid succession; but the chief danger in such a case is the formation of a second contact to ground. The induction coil which at the same time had a contact to the primary line would necessarily take the potential of that line, and we will suppose the ground on the other side of the line. Now, a person may go to the lamp under those conditions and his fixture might be near a metal object, it might be connected by moisture; he might stand on the moist floor and the result would be the current would come down through his body and he would be subjected to the full potential; and there is no doubt that if he should be foolish enough to stay there he would have to stay there until somebody took him away. But a man when he is shocked generally drops away from the thing that shocks him, but he may be, as we term it, "hung up"; that is, he cannot let go, and that is undoubtedly the reason why accidents happen in arc light distribution. If a man can get away at once even such a potential as 2,000 or 3,000 volts will not kill him; as we have had plenty of experience to prove.

To avoid such dangers in alternating current lines we provide a very simple means. We take our secondary here and ground it. If the insulation between the primary and secondary is as good as it ought to be at all times, the grounding of the secondary will not hurt anything; that is certain. What then occurs? If the man takes hold of the secondary wire and touches a radiator connected with the ground or a water pipe, he is already shunted by a good conductor and he cannot get anything to hurt him. Put this wire to your steam radiator or water pipe. That addition to the system would save us from all shocks: but it would introduce another element of irregularity and danger; that is, it would provoke contacts to the secondary line; but nevertheless if a contact does occur cut your line off altogether by putting a fusible plug in the circuit leading to the primary, so that if there is any diversion of current through to the secondary and to ground, the plug will blow out. There is another danger of course in having this ground connection and that is the danger of atmospheric discharges —lightning, etc. That, however, can be avoided by making the insulation here heavy, and in fact separating the wires by an air space and then putting near the primary line where it enters the building, or in any convenient points an ordinary lightning arrester in which the spaces between the line and the conductor to ground are so small that an atmospheric discharge will seek the ground through that and not through this. Of course it would be necessary in running such a system to test it for grounds just as lines are tested to-day. [Applause.]

MR. CHURCH:—My proper office here would naturally be to defend the secondary system, otherwise the converter system, against attack; but I find that there has been no serious objection raised. In fact there seems to be a unanimity of sentiment in favor of it, insomuch that it seems to me if we were placed in series we might generate 4,000 or 5,000 volts electromotive force in the way of commendation of the system.

With reference to the opinion of Doctor Siemens, I have only to say that I should reply to his criticisms by subscribing my fair share toward paying his passage to this country to see the thing done. [Laughter.] I was recently at Daly's Theatre and witnessed that charming production of Shakespeare's "Taming of the Shrew" and I noticed that *Petruchio* insisted that he saw the sun, in defiance of the fact that the moon was shining; and it strikes me as ridiculous (if I may be allowed to couple that term with so distinguished a man as Dr. Siemens), to state that the secondary converters will not govern within better than a range of four per cent. in defiance of the fact that the company with which I am associated is operating these converters commercially and deriving its pay from the plants. The whole thing is reduced to an ordinary matter of fact. The variation is not appreciable by any of the instruments that we can bring to bear upon it outside of the laboratory. We are putting in 100 volts and taking out better than 98 and selling them to people and getting our pay for them. I contend that the final touchstone in the eye of the practical man; and more important in the eye of the man to whom we sell is, "Can I take this system, disregarding the *whyness* and simply secure the result and put it in my vest pocket."

The question has also been raised as to whether the distribution upon this high potential system, coupled with underground circuits, might not be essentially as bad as on the ordinary multiple system, eating itself up in capital before going out to any considerable distance. Let us look at it from the commercial standpoint. Copper is not the sole element of economy by any means. In fact I think there has been an injustice done to the secondary system by insisting that its prime usefulness lay in the reduction of the first cost of street wiring. That is one way to put it, but I think it the least forcible way. As I judge from daily contact with it commercially, the usefulness of this system is largely in extending your business from a central station to the remotest point. You have certain fixed expenses—I am now talking to you from the standpoint of the man with whom I deal—these expenses consist of salary accounts, investments in buildings and real estate, and interest and depreciation, and what not. Now, you wish to dilute that expense as far as possible and to make it bring you in a large amount of business. Therefore, if it were true,—which permit me to state it is not by a large majority,—that the increase of the cost of copper was in any such ratio as has been alluded to by Dr.

Siemens, it still would leave untouched the fact of rendering the other fixed expenses of the intsallation available for the increase of business. That fact has been commercially proved with us beyond peradventure.

The use of the converter or high potential system, permits the running of wires on a very small percentage of drop. With the ordinary multiple arc system and low potential, your copper is so large at best that you have got to submit to ten or fifteen per cent of drop to secure a reasonable amount of copper at all. The converter system on the contrary enables you to run with a two per cent. loss in the primary mains and bear in mind that that saving is a merchantable article. Instead of sacrificing a certain amount of the energy of your plant in your lines, you take it out and sell it to a customer and put the dollar in your vest pocket. Furthermore the low drop has an enormous effect upon the life of the lamps, which is again a commercial question. Furthermore the secondary system enables you to maintain an almost absolutely uniform potential throughout your distribution.

Thus I might drift along, touching upon a host of points which are in no sense scientific and yet seem to me to carry much weight, if we consider the question in its practical and every day aspect. I am pleased to say that so far as our work has progressed—and we are treating it entirely on a commercial basis—no serious difficulty has arisen that we have been obliged to overcome.

Professor Thomson has alluded to one other feature of the system. He states that one of the characteristics of a certain form of broken current is that it discourages your moral nature entirely, by the intermittent and very sudden and unexpected changes it takes on. On the contrary, he goes on to say, the peculiarly rhythmic and wavy motion of the alternating current is a tranquilizer, and the alternating machine may therefore be said to be a moral agent. I have noticed the effects upon my own moral nature since I have been in the business and I confess I was unable to account for it until this moment. [Applause.]

Mr. Ralph W. Pope:—One of the objects of the Institute, I presume, is to do justice to all systems; and, as that particular system which is affording us radiance this evening has furnished a text for two or three of the speakers, on account of its winking and blinking, I might say in explanation that this plant is operated by a dynamo in the building. But that is not the point I wished to bring to your notice. This scene of revelry has now continued to such a late hour that, on account of the departure of the engineer, the dynamo is not equal to the emergency, consequently, earlier in the evening, the lighting was switched from the local plant to the central station system, and this switching operation caused the blinking which we saw.

Dr. Moses:—I stand corrected. The remarks of Mr. Wetzler with regard to Mr. Siemens's criticism, recalls to my mind something that occurred in which Mr. Siemens figured. For some reason or other Mr. Siemens did not like Mr. Edison—until their interests finally became the same in Germany. I heard Mr. Edison's agent (who was present at an interview with Mr. Siemens when the business was settled) say that Mr. Siemens had remarked: "Well, I never did think that I could be made to reconcile with him, but you see what a man's interest will do." May we not on some future occasion listen to a similar conciliatory remark from Mr. Siemens about secondary distribution? Mr. Church cites a case from the "Taming of the Shrew," which is very apposite and recalls to my mind another anecdote. Once a very stubborn sort of man got into difficulty. He owed money to a person who had him arrested for debt. So he said to the bailiff: "Look here—this is an absolute impossibility. You cannot arrest me. My lawyer says you can't." "Very good, I will arrest you and take the risk." So the man was arrested and he wrote to his lawyer saying: "How is this? You told that me I could not be arrested for debt." "The fact is," said the lawyer in reply, "You can *not* be arrested for debt." The prisoner writes back: "The fact is I *am* arrested for debt." Now, Mr. Siemens may talk about four per cent. fall of potential rendering incandescent lighting impossible by secondary generation, saying that the bringing down of its potential from 104 to 100 volts would be so noticeable a thing that people would not use that lamp and so on. But the facts are, as I have seen them in South Pittsburgh, people were using the lamp. The lamps were prisoners; they were there, all that Mr. Siemens may say to the contrary notwithstanding.

There were one or two points Professor Thomson referred to that are very interesting, which I will advert to, parenthetically. He says (making a sketch) if there were waves of small amplitude intercolated in these alternately rising and falling variations, there would be produced a kind of kick upon the ear that would be audible in a telephone He will recall perhaps a remark that Professor Tyndall made, when on one of his excursions in the Alps with a companion and hearing an exceedingly shrill and ear piercing noise, said: "What is that deafening sound I hear?" The man said, "I do not hear anything at all." Professor Tyndall looked at his companion, in amazement. "You do not hear that sound?" he said. "No" said the man, "I hear nothing." Well, it was a question of fact; and Tyndall tried to explain it—and did explain it very reasonably—by saying that his ear was tuned a little higher than the ear of his companion and that the grasshoppers which had collected in great swarms in his neighborhood and were producing this fearful noise, emitted a note of so high a pitch that his ear could hear it, but his companion's could not.

Now, if you calculate the variations there are in an ordinary alternating circuit, they will amount to about 250 a second. Two hundred and fifty variations a second would make a very pleasant musical tone; but these minor waves would be so small compared to the whole amplitude of the main waves that they would be altogether inappreciable to the finest tuned ear. So I doubt whether these supposed rises and falls on the larger waves would produce an unpleasant sensation.

There is another point that I would like to call attention to. Mr. Church referred to running wires overhead. I think that very serious consideration ought to be given to that point. While the underground commission is still undecided in its action, the electric light companies should determine whether it is absolutely necessary for wires carrying alternating currents or currents of very high potential to go underground. I think there ought to be a distinction made. Although an alternating current may not injure a telephone, still it is not every current that is perfectly uniform or harmless. There may be changes in it that might introduce some disturbance, and such things should be avoided. For that reason, it would be well for the whole electric lighting interest to unite in calling attention to the fact that it would be better to leave the air to the distribution of high potential currents for lighting, and to take the earth for telegraphic and telephonic distribution and the distribution of power. There ought to be a dividing line between the two classes of currents.

Professor Thomson made a very interesting allusion to the interaction of the waves of electricity sent off from both primary and secondary coils, which induces me to pay a tribute to the one who made, I think, the first observation of that action, by recalling to mind that article of Faraday's in the Philosophical Magazine (1831), in which he announced the discovery of voltaic induction, when recording that a current brought over a parallel closed circuit will induce a current in a neighboring wire. He then gives a fundamental experiment. But he makes one leap there which must be filled out by the imagination of the reader. It is a marvel to me that a man would accomplish so much and pass it by in perfect silence; but the experiment itself proves that the very pretty deduction that Professor Thomson made must have passed through the mind of Faraday at that time.

Faraday passed his current through the primary and he took off a current on the secondary neighboring wire by joining its ends—making a closed circuit. The first experiment that he records was this:

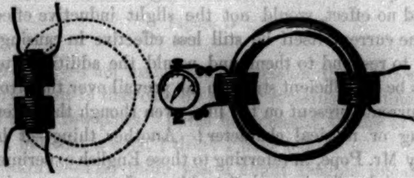

Figure 6.

He noticed that the lines of force emanating from that iron core—external lines—passing here were weakened by the poor conductivity of the air and reasoning out that the lines that were cut by the entrance of this current into the primary coil from an infinite distance, cut the magnetic lines that were induced through the iron across into this coil, he closes up at once his circuit, makes an iron atmosphere for it and he gets a closed ring form. Thus the first experiment that he records shows that he thoroughly understood that the rushing up of the current from an infinite distance produced lines of force that were cut in the opposite direction through the ring of iron by lines generated in the secondary which as Professor Thomson acutely stated, were really a part of the primary.

Mr. Ries:—It has been stated by Professor Thomson that the alternating current that he used, on account of its undulating character had no detrimental effect upon the telephone wires running parallel with it. I should like Professor Thomson to inform us what the potential or electromotive force of this alternating current was. It has also been stated that this undulating movement was a gradual one in contradistinction to the jerking movement caused by the intermittent current. Now, it is known that the diaphragm of a telephone will vibrate a certain number of times per second, according to the number of alternations in the primary. The stronger the positive and negative impulses on the primary circuit, the stronger it would seem will be the magnetic attraction, and consequently the amplitude of vibration of the diaphragms on the telephone line; so that taking that further modification of Doctor Moses, in which the undulations due to induction were described as being in the nature of a very rapid wave motion, having an independent action that would have no effect upon the diaphragm. Now, if these high tension induced undulations had no effect, would not the slight inductive effect of the telephone current itself be still less effective in causing the diaphragm to respond to them, and would the additional telephone currents be of sufficient strength to prevail over the stronger induced currents present on the line, even though the latter be of a humming or musical character? Another thing—it has been stated by Mr. Pope, in referring to those English experiments, that the *rectangular* line caused disturbing effects upon neighboring telephone wires, etc., whereas when the line is put into the form of a parallel metallic circuit the incoming currents neutralize the outgoing currents to such an extent that their effect upon the neighboring telephone and telegraph lines was not noticed practically. If that is the case, is it to be assumed that on a metallic circuit the interruptions—the alternating impulses will oppose each other and thus reduce their mutual efficiency, or are they only active with respect to the surrounding telephone and telegraph wire.

MR. FRANK L. POPE:—Before asking Professor Thomson to reply to Mr. Ries, perhaps I had best show by diagram the arrangement of the wires in London. (See figure 7 on next page.)

The original arrangement was something like this. Suppose *a* to be the station. The telephone lines crossed the loop in all directions. The wires were in all cases put on the tops of buildings—although we are told that "they do not have any overhead system in London." Yet this lighting system is all overhead. The diagram now shows the arrangement that is in use which prevents interference with the telephone. The Westinghouse Company used a line at Pittsburgh some two miles long or more, which went on the same poles as the telephone lines, but did not prevent conversation from being carried on through the latter.

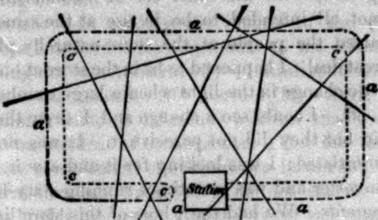

Figure 7.

Mr. Church:—I am under the impression that we reached a satisfactory result in that case by simply crossing our lines at intervals of every few poles. I was not present at any of the experiments, but that is what I think I have heard.

Mr. Wright:—Yes, there was a slight trouble due to that, but it was overcome by crossing the lines, I think, about four or five times. At Plainfield I have no trouble. I cross my lines at every third pole. I started at Plainfield to put in the old system of direct current and Mr. Westinghouse came one day and told me to remove my machines and install the alternating system. I knew nothing of that system at the time. We put up a 650 light machine, and we have now wired the business portion of the town. We have running at present some 450 lights. I went down to Pittsburgh and was there for a couple of days and saw a thousand lights running three miles from the factory. I returned after spending a couple of evenings there, and two months later I had my station in order. I started there with green men. When I was ready, I signalled to the engineer to start, watched my volt-meter and went out to look at my lights. They were all running well and since that time we have had no trouble whatever with our machines or circuits. We started on the 1st of February. With regard to the variation in potential due to the different loads on the converter I had a little experience. In Plainfield, all my converters are connected in the primary circuits and having there a few converters at first, I connected all my converters on the secondary circuit and took my services into my stores from the secondary wires. In one case I had one converter working independently and I had wired on that 53 lights in one store and 16 in the other. This was on a side street and I had no means of connecting it up with the other set of secondaries. The 53 lights were not all intended to be in use at the same time, but when we started the people at the store naturally played with the thing a great deal. I happened to be in the store at one time and I noticed a little change in the light when a large number of lights were turned off. I could see a change and I drew the attention of others to it, but they did not perceive it. It was not perceptible to the uninitiated; I was looking for it and saw it. I had a fifty-light converter and was sometimes running sixty lights on it for a few moments. We had the whole of this store lighted continuously. I cannot say anything about the measurements, because I have no means of making measurements down there; moreover it is not in my province, as I am dealing with things in a practical and commercial way. As far as regulation is concerned, we have no regulation in our station to speak of. When a large load is taken off, we vary the current from our exciter slightly, but there never is so much load taken off at one time as to affect that very materially. We take readings about every fifteen minutes; that seems to be about as often as is necessary. We have had no trouble with the armatures. One armature went in the first day and is there yet. It has been running now since the 1st of February on an average of fifteen hours a day, and I have no spare armature. I do not know how many lights I have running now. When I returned last night there were some four or five stores added to the circuit. Plainfield has been without a license law for some time and my income was to be derived very largely from the saloons. We put on five saloons last night, during the heaviest part of my load about half-past eight; so that my load somewhat increased last night. (Laughter.)

Mr. Wheeler:—I am not sure that I understand what Dr. Siemens's objection is, but from what Mr. Wetzler says—that the system would not regulate within four per cent. I imagine that he means that when the load of lamps is increased the increase of current would cause a greater loss of potential in the coil. If that is the only difficulty, I do not see why that cannot be overcome. The converter coils seem to work very well indeed and I do not see why they cannot be handled in just the same way as a dynamo is handled. If they won't regulate, why cannot they be made to regulate? For instance, if the loss is due to increasing the number of lamps why can't the coil be so arranged that as more lamps are turned on, more coil is turned on, or why could not a differential wiring be used?

MR. CHURCH:—In reading the reports of the convention at Philadelphia I noticed some statements to the effect that we had been burning out armatures rapidly—I think something like twenty a month was named. My partner, Mr. Kerr, replied very properly that it made no difference whether that was so or not—that it was an incident of construction. But the fact is that out of the entire complement of stations we have running, we burnt our first armature last week. We do not exactly know what it was due to at this moment. But the meter was reading some 65 amperes on a machine calculated to run but 45 amperes and there was a short circuit somewhere that was taking an immense amount of current. The armature of course gradually heated up and burned out, and the people on the circuit knew nothing about it. That was the first burned out armature, outside of our own experimental work in the shop. We have ripped out two armatures by simple mechanical contact. The binding wires got against the pole pieces and simply stripped off from the armature without the slightest burning—purely a mechanical action. A statement was also made that we were suffering enormously from the short life of the converters. The simple truth is that we burnt our first converter about ten days or two weeks ago.

MR. MARTIN:—I would like to ask Mr. Wright in regard to the distribution of these converters. My friend Duncan, in Pittsburgh, is very well pleased with a secondary generator plant there and stated at the electric light convention that he had one of his converters on the poles but that in one or two cases he did not think it necessary to have them attached to the building.

MR. WRIGHT:—At present my converters are on the poles. My lighting is scattered and I have not a large number of converters, but I have more than sufficient in total light capacity. They are sometimes about four or five poles apart, (the distance between poles averaging 120 feet,) a great deal depending upon the disposition of the lighting. Of course I may have occasion in some cases to place my converters in the interiors of buildings but generally outside the buildings. I propose in Plainfield, in the residential portion of the town, to run my branches from the sub-mains into the central portions of the blocks to distribute from that point.

I forgot to mention that I am running in my station at 104 volts. My line is calculated, in the business portion of the town, for 1500 lights. Of course the business portion of Plainfield is not very large and my loss was intended to be 1 per cent. on the primaries, but I happened to have some old arc wire that I wished to make use of, which increased my loss about one quarter per cent., so that practically just now I am not getting my loss in my primaries on account of having 400 lights where I am wired for 1500. I have got about 1 per cent. of loss on my secondaries. My lights are well up to candle power with 104 volts in the station. In fact people tell me my lights are over candle power. As I say, my voltage is 104 in the station. At present I am simply regulating by station lights where the loss is practically *nil.*

Mr. Ries:—Are the primary coils of the transformers connected in parallel?

Mr. Wright:—In parallel.

Mr. Ries:—And you find the regulation for that reason better; that is to say, any variation in the circuit of one transformer will not affect the secondary circuit in the other; the parallel connection tends to facilitate the vertical regulation.

Mr. Wright:—Certainly. Although it is not generally intended to connect the secondaries, I should do so in the business portion of the town. I shall insert other converters as my light increases.

Mr. Mailloux:—I would like to have somebody tell me whether anything has been done to develop the application of the secondary transformers for distributing power by motors. Dr. Moses has told us that he could send one impulse to, and the other fro in the same circuit. It would be interesting to know whether this to-and-fro matter is only theoretical, or whether it is practical and has been accomplished. I would also inquire whether in the event of a system of distribution by periodic impulses of one polarity on each circuit, the size of the transformer and to a certain extent the method of its application would not need to be changed to conform to the different manner in which the energy would be distributed, because we shall have now energy being supplied by the circuit for only half the time, and of the energy so supplied we must store enough in the induction coil to maintain the supply during the other half. In other words it must produce a certain magnetic reaction which will be sufficient to keep up the energy during the remaining half.

A Member:—Wasn't it generally considered settled at the last convention of the Electric Light Association, by Mr. Sprague, that the economical transmission of power by electricity could not be arranged on an incandescent light circuit, and it was necessary to have a separate plant for that purpose?

Mr. Mailloux:—As I understand it, the means by which we distribute energy by use of transformers are so different, and each transformer is to a certain extent so completely isolated in regard to its action from the rest, that if we find a solution, adapted to the transformers in general, I do not see any reason why this solution would not admit of the common use of motors and lights on the same circuit with equal efficiency. It is therefore for that reason I bring up the question; that is a point on which I have no doubt we are all in the dark and about which we would all like some information, and as a practical man, I would like to ask that question.

I would also like to know what has been found in practice to be the difference in efficiency between the coils of the ordinary straight description and that of the circular form, which is generally used in installations for distributing energy by means of transformers. I have had this question submitted to me lately on several occasions, and I was of the opinion that the difference in efficiency would not exceed two or three per cent? I would like to know whether any such data has been obtained from practice.

Mr. Frank L. Pope:—I think the question which Mr. Mailloux refers to was pretty thoroughly investigated by Professor Ferraris. The result was something like this—that there was no very great difference in the co-efficient of transformation, but there was a much smaller amount of iron and copper required to do the work with the closed core than with the open one.

Mr. Mansfield:—The subject of the distribution of electricity for lighting purposes has been pretty well handled by those interested in converters; but I fail to see exactly of what use the converter is commercially. In the installation at Plainfield, we have not such a great distance to annihilate; and all men who are engaged in the transmission of power, and I am one, talk about annihilating space. Mr. Wright, I think, spoke of using the converter right in his own station. Now I do not see that there would be any economy there over the direct system, unless when you go to a distance you want your alternating currents or your high potentials there so as to annihilate this distance. You put in your converters or transformers so as to get the electromotive force down to a safe working basis; but with motors I presume that the same converters can be used. But I do not see just how the economy comes in, in using the converters so near the station. When I first started in the electrical field, which was only a short time ago, I heard Dr. Moses speak in the most glowing terms of placing some sort of an electrical machine in the bottom of a coal mine, in the wilds of Pennsylvania, and transmitting the energy to New York and utilizing it for our lights. I thought that was a grand scheme. But of late I have had to figure somewhat on transmitting energy to a distance, and I met in connection with that recently an exceedingly practical man. He asked me if I could transmit to any distance any amount of energy. I said yes. He wanted to know how far. I told him any distance he wanted, and he specified twenty-five miles, and he went a little higher, and I thought I would keep on as high as he did. Finally he got to a certain point where he smiled to himself, and asked me if I was aware of another method of transmitting energy, so to speak, but energy which was tied up. Well, I did not see just what he meant and I said no. He then spoke of the great railroad system which we have now, and that set me thinking, and I went home and commenced to figure, and from the census reports I learned that the cost for transporting a ton of freight on some seventy-nine of the greatest railroads in the country, if it was figured down on the basis of per ton mile, was only about seven mills. Well, you can easily figure from that basis that a railroad will be a formidable rival, if you went up into twenty-five or fifty miles even. They could transfer the coal from one place to another, burn the coal in their furnaces and produce their energy through furnaces and through steam much more cheaply than we could transmit that amount of energy electrically.

Mr. Mailloux:—How about water power? If there is a natural source of energy, how are you going to get that to a distant town?

Mr. Mansfield;—The natural sources of energy in this country are to a certain extent mythical. If you will consult the census reports you will see that there is not so much water lying around loose as some people think, and that the Lowell mills and the Lawrence mills and the Paterson mills and the mills at Holyoke, and so on, all have steam engines. In my opinion a station established with the ordinary arc light potential in the middle of New York city exactly in the center of the longitudinal axes of the island would quite easily handle the motor problem in the entire city and at even a less potential than they are using on some of the arc light circuits. The existence of danger is another question. But I think that can be simply answered by the fewness of the lives lost on the arc lighting circuits. So that after all, perhaps right on the arc light circuits we motor men have a means for carrying on our business without interpolating converters.

Mr. Wright:—The last speaker made a remark regarding a converter in the station. I can hardly light my station without a converter, seeing that I have a thousand volt machine and my lamps are 100 volt lamps. My lines in Plainfield at present average about five thousand feet from the station and I am laying out one line which will be four miles from the station.

Professor Thomson:—In regard to the economy of wiring, I think that you may say that taking high potentials and distributing in multiple arc, there is a good point just there; when we use an arc light circuit we have to take the whole current all around the circuit; that is, the wire must be large enough to carry with a small loss the whole current which may be five miles away. When we take a multiple arc circuit at high potential the energy is given out here and there; we do not carry it any further; but the amount of copper needed will be very much less to carry the same energy than on an arc light circuit. Take it at the equivalent electro-motive force, and assume that your work is done over a district pretty evenly. and you are practically delivering say an energy equal to ten-horse power at a block or two away and that energy has not to be added to the current which is traversing the whole line; it is dropped right there. Now the energy which goes further is carried by the current, and so it goes; so that there is really an actual saving of wire and a considerable saving over the wire used on an arc light circuit.

In regard to induction, I may say that the system which is figured on the diagram has a double wire going out and returning which is almost a necessity in the running of our plant. Almost all arc light circuits go and return on the same poles and the nearer the outgoing and returning wires are placed the better it will be. But as we cannot place them close together, we can do the next best thing; we can interchange their positions—cross and recross back. All that we have to do is to produce such a condition in the wiring as will not give an effective magnetic field which can act on the other wires, or if we do get magnetic fields which will get on the other field, we must use opposing ones. In arc lighting it has been found that all that is necessary to do is to run the wires parallel and very little effect is then produced on any neighboring wires.

With the alternating current machine, you can turn up and down a lamp without the loss of energy amounting to anything. Now that seems a surprising fact, but it is true. The lamp may be run just as you would a gas burner; turn it down so that the filament is red, by a little attachment no bigger than my fist. It is simply the interposition of a very little coil—not an induction coil—sheathed in iron and the capability of putting more or less wire into the circuit; in other words introducing a good converter of electromotive force into the circuit, which will prevent the current going through the lamp, and which will do that, not as a resistance in the lamp, but by throwing the electromotive force back on itself. That can be done to a single lamp or it can be done to a group of lamps.

On the continuous current circuit there has been and is a continual strain after high volt lamps. It is regarded almost as impracticable to run any distance unless you take one hundred or one hundred and ten volt lamps, the highest that can be commercially made. The reason is that when you get beyond that, the filament will almost sag by its own weight, and the one hundred volt lamps that are made to-day are generally of a low efficiency, compared to lamps of lower volts which will give exactly the same life. A fifty volt lamp, for example, can be made to use less energy than a one hundred volt lamp, and give the same light.

Mr. Wright:—About three watts as compared to four or even less.

Professor Thomson:—But when you get much below three watts you sacrifice life considerably.

In regard to the regulation, a station operating on a continuous current system over any distance has a drop which will amount to probably ten, fifteen and sometimes even twenty per cent., and that is the case especially where the object is to save wire, and where the fuel is pretty cheap, and where they can afford to run heavy losses on account of fuel being cheap. On the alternating current system the drop can be made certainly very much less on the drop line. The drop in the induction coil itself is altogether within our control; at least so it appears to me. The high work which is obtained from the wiring makes the resistance of the wire bear such a small proportion to the actual electromotive force at work and to the resistance of the circuit on which it operates that there is a practical regulation. The local line, of course, can be wired so as to give very little drop without involving the use of a great deal of copper.

As to the motor question I think that the alternating current motors can be made to run nearly as efficiently as continuous current motors, and with the saving of drop in the mains we can afford to run them less efficiently. It is not absolutely necessary to change the high potential current by an induction coil for the motor. If the motor is built to stand the potential in the main circuit, there is no need of reducing the potential.

MR. CHURCH:—Except as a matter of personal safety.

PROFESSOR THOMSON:—That is all. But it seems to me that as the alternating current motor is an apparatus that has not got a commutator, necessarily the machine may be boxed up and run with fair safety. The only difficulty about running motors is getting them started. The fact is, that if the impulse comes at a certain rate, unless the motor takes that impulse at the same rate, it will not start; that is you must give it the speed first; you must put it in tune with the rest of the circuit by giving it the speed; than clap on the current and it will run at that speed absolutely. If you overload it, you will draw it down and it will stop. Now, I have in my possession a little machine which, put on an alternating current circuit, will start from the state of rest and run right up to speed, developing considerable power. That machine may not be as efficient as the alternating current motor is, but I can put that little motor on the same shaft with the larger motor and give it the speed of that little motor, having the whole thing under my control. (Applause.) I take off the load from the motor and I put this little motor in circuit, and I put the larger motor up to speed in that way and then throw the current on to it and throw off the smaller. I am not at liberty to describe in full that arrangement. As yet it is not fully developed, but I hope before long to have it in such shape that it can be fully discussed.

Adjourned.

GENERAL MEETING.

May 18, 1887.

The meeting was called to order in the rooms of the American Society of Civil Engineers, 127 East 23d Street, New York city, at 10.45 A.M., by the retiring President of the Institute, Mr. Frank L. Pope.

Mr. Pope addressed the meeting as follows:

Members of the Institute and Gentlemen:

In bidding you welcome to the fourth annual meeting of the Institute of Electrical Engineers, it affords me much gratification to see such a large and representative attendance, and to note the evidently increasing interest manifested by the electricians of the country in the welfare and prosperity of our organization.

The year which has elapsed since our last annual meeting has proved one of unusual prosperity in all branches of legitimate business having to do with the manifold industrial applications of electricity. Without exception, so far as I am aware, the manufacturers of electrical machinery, apparatus and supplies are all fully employed; some of them are working overtime, and many of them have in contemplation or actually in progress extensive additions to their facilities.

While rapid development, enlargement and extension seems to be at present the rule in every department of the science and art which we, as an organization, especially represent, it may not be amiss to refer to the exceptional progress which has been made in certain specific directions since our last meeting. Among these may be mentioned the transmission and distribution of mechanical energy through the agency of electric motors, and especially the application of these to minor branches of manufacturing in large industrial centres, and to the propulsion of street railroad cars; the largely extended employment of accumulators or storage batteries for the lighting of buildings and railway passenger cars; and the introduction of long distance incandescent electric lighting, which has at length apparently been made both practicable and profitable by the employment of alternating currents and induction apparatus. Last, but not least, should be mentioned the new art of welding metals by the aid of the electric current, which seems likely to occupy a vast and immediate field of usefulness, and to create numberless new industries, to say nothing of revolutionizing some of the existing ones which have come down to us almost unchanged from the days of Vulcan and of Tubal Cain.

I am sure that it will be a source of gratification to you all to learn that the prosperity of the Institute of Electrical Engineers has kept fairly abreast with that of its members and co-workers in their individual and professional capacities.

The series of special meetings, each preceded by a dinner, which have been held in this city, during a portion of the past year, have proved to be most successful and enjoyable reunions, and have certainly done much to strengthen the Institute, by increasing the interest of non-resident members as well as of those residing in the more immediate vicinity of New York.

Several exceedingly interesting discussions, which have taken place at these meetings, have been reported in the professional journals on both sides of the Atlantic, and thus the information brought out has been made available to the profession generally. It is proposed to continue this commendable innovation during the coming year, and I have no doubt but it will henceforth become a permanent feature of our proceedings.

The courtesy and liberality of our much-esteemed sister society, the American Society of Civil Engineers, has enabled us to enjoy for another year the hospitality of the convenient and comfortable rooms in which we are now assembled.

While I feel sure that every member of the Institute appreciates to the fullest extent the value of the assistance which has thus been rendered to us as a society in the days of our youth and feebleness, yet in the judgment of some of our most esteemed members the time has arrived when we may feel justified in making a determined effort to secure adequate, commodious and convenient headquarters of our own. Within a day or two past, a movement has been set on foot to raise the necessary funds to carry out this project in a fitting manner, and I am more than gratified to say, with excellent prospects of success. The undertaking will be presented to-day in a definite form for the consideration of the members, and I feel certain that each and all of you will individually do everything in your power to insure its early and complete success. It is hardly necessary to say, that the establishment of the Institute in a building of its own, equipped with a library, reading-room, and perhaps ultimately with an experimental laboratory, will give us a standing second to that of no other institute in the world, devoted to a special branch of art or science; it will directly benefit every industrial enterprise in the country having to do with electricity; it will increase the confidence of capitalists in the importance, remunerativeness, and stability of electrical enterprises, and will in every possible way be of the utmost advantage not only to our own members, but to all who are in any way connected with electrical enterprises. I trust therefore that my successor in the honorable position of President of this Institute may be enabled to signalize his administration by the completion of this most desirable undertaking.

In conclusion I desire to tender my acknowledgements to the officers of the Institute and the members generally for their kind and hearty co-operation in carrying on the affairs of the organization during the past year.

MR. POPE:—Gentlemen, it gives me great pleasure now to introduce to you the newly-elected President for the coming year, Mr. T. C. Martin, whom you all well know.

PRESIDENT MARTIN then read the following address:

Fellow Members of the Institute:

Your action last night, placing me next in succession as President to so distinguished an electrician as Mr. Frank L. Pope, and so soon after Dr. Norvin Green has occupied this chair, is one that only the results can justfy. Although my connection with the Institute dates back to its foundation, and although in the three years of its existence I have been afforded the opportunity of participating in its management, I cannot venture to regard your decision as entirely personal. I would interpret it rather as a generous recognition of the fact that the Institute has still the larger part of its initial work to do, and that work must be carried out chiefly by the younger element, which constitutes an ever-increasing part of the membership. For this great honor, and for this sign of your confidence, my thanks must, therefore, find their best expression in what the Institute achieves during the current year.

We stand to-day at an important stage in electrical investigation and development, and yet it is not given us to see or to say what will be its position in the long vista or perspective stretching through the second half of the present century. As Dr. Priestley reflected one hundred years ago: "It may be said that there is a *ne plus ùltra* in everything, and therefore in electricity. It is true, but what reason is there to think we have arrived at it?" Priestley was of those who were permitted to gaze afar off at untrodden fields of discovery, but who did not enter in. To-day the evidence of what has been achieved tells us that the greater lies before. The time is one, in fact, when science, and such a department of it as ours, offers to the more adventurous and inquiring spirits the rewards that were once mainly to be found in geographical discovery and in the prosecution of trade, but which are wanting now when even the interior of Africa has been traversed, and when commerce is carried on at apparently a diminishing rate of profit to capital. The electrician has gained, meanwhile, a foothold on the Atlantic seaboard of his new continent, and, subduing a wilderness of theory, speculation and doubt, has already won some of the noblest provinces that ever rewarded the industry and the genius of man. But beyond him lie the ranges of distant mountains, and westward of their peaks is the territory out of which he has yet to carve a score of states unnamed. Toward that great west of his science, the electrician advances, and even now he has the first fruits of exploration. But while there is this onward movement for the pre-emption and occupancy of virgin soil, we see going on an equal development in the realms already won, invention being heaped on invention, and improvement added to improvement. Speaking as one who had witnessed this change, Dr. Werner Siemens said recently: "We still remember the time when we listened with incredulous wonder to the strange fairy tale that the mysterious new force, electricity, could transmit messages with lightning speed across whole continents and the oceans which divide them; and that this same agent could precipitate metals in a solid form from their solutions and change night into day;" and yet, as he went on to point out, this is not less the time "when the world-encompassing telegraph no longer suffices for the needs of intercourse, but must give place to the transmission of oral messages by the telephone over distances, in comparison with which the natural range of the human voice appears as nothing; when the latest fruit of the union of science and technology—electro-mechanics—in its rapid development, offers to mankind ever new and immeasureable fields for investigation and utilization of the natural forces."

We are dealing, however, with the immediate present, and have to keep pace with such a rapidity of achievement that our plans each day have to be adjusted to larger conceptions and wider horizons. The position was admirably described this month in a leading magazine, by Mr. Geo. B. Prescott, Jr. "The improvements of methods," he said, "the refinement of machines and appliances, and the bringing of science down to daily work and business, moves on so swiftly that the new machine, or the new one of a year ago, is already old. The reduction of refractory ores in electric furnaces, where immense carbons, fed by the largest dynamos in the world, give a heat never used before, excited world-wide wonder only a few months since. * * * * Even the very recent railroad accident in Vermont has created a demand for storage batteries for lighting lamps in cars that is so active that every railroad shop in the land is examining new accumulators. Never in the history of any business was there such an eager desire to obtain new machines, new tools, and new methods as in the manufacture of electrical apparatus." This is well put. In fact, the electrical statistics of to-day are nothing short of colossal. To go no further than our own country, we find an investment and capitalization in simply the leading electrical industries—telegraphy, telephony, electric lighting, and electric power—of a sum of, at least, $350,000,000. There are in America about 700,000 miles of telegraph wire. Last year 320,000,000 telephonic conversations were held. Over 150,000 arc lamps, and incandescents verging on 1,000,000 now instruct the public eye that the electric is the light before which all others must pale their ineffectual fires. At least 10, 000 electric motors are employed in the most varied industries, and while the electric railways here are carrying passengers at the rate of more than 3½ millions annually, the extraordinary increase now going on in that branch promises that the figures will be doubled within the year, with at least from 50 to 75 electric roads in operation. When to these figures we add the thousands of dynamos and vats used in electro-plating, the countless electric appliances used, in medicine, surgery and the miscellaneous arts, and the endless variety of electrical apparatus for convenience, safety, protection and comfort in the house, office, train or hotel, we arrive at sum totals dealing with which a statistician needs all his ability to mass and classify. It is no exaggeration to say, moreover, that in the electric industries, hundreds of thousands of our most intelligent citizens of both sexes find remunerative and agreeable occupation; nor is it an exaggeration to affirm that at a time when all great departments of manufacture must depend for success on the degree of technical culture and skill displayed in them, none rests on a more strictly scientific basis than ours.

Where in the midst of all this activity, where in the sphere of so much outgrowth, onlook and uplift, do we find the Institute? That is the question for us to answer. The Institute has in its three years of life done good unobtrusively, but it is not discharging its reponsibilities nor carrying out its mission to the full. Our fellowship, though growing rapidly from among those already active in electrical pursuits, must be greatly enlarged to embrace the constant accessions to the electrical ranks. Cornell University alone has now 59 students in electrical engineering, and those young men as they enter on practice feel the need of association with the men already at work. Stevens Institute is sending out numbers of capable electricians, and but the other day I had the pleasure of meeting the zealous and enthusiastic "electricals" of the Massachusetts Institute of Technology. For all of them, and many others, we must provide a place in our membership.

But with an expansion of the Institute must come, as my predecessor, Mr. Pope, said last night, proper accommodation for the books, apparatus, portraits and documents of the Institute, fitting quarters for the Secretary, and a place to preserve the numerous relics and mementoes which are to be given us, but now lie dusty and neglected and widely scattered. The Institute must have a local habitation as well as a name. It should also, as suggested in a resolution adopted by you, be incorporated at as early a date as possible.

Another matter of importance is the strengthening of the ties of friendship between the Institute and kindred societies at home and abroad. We have here no end to serve but the promotion of science and industry, and to that end we are endeavoring to devote our energies with singleness of aim and purity of purpose. I would be glad to see steps taken so that any member of the electrical bodies abroad shall be entitled, while in America, to enjoy all the facilities and resources of the Institute. I would esteem it a great privilege to be in any way instrumental in more closely uniting the organizations here at home. I may particularly mention, in this respect, the New York Electrical Society, which, though local in work, is the oldest of the kind and has made a most creditable record. The feeling toward us on the part of that society is heartily kind and fraternal, and I do not see why the two bodies cannot be brought together, and, perhaps, by compromise and mutual concession, benefited in a close union. The first approaches have, indeed, been taken in the membership enjoyed by a great many of us in both organizations.

I might touch on other topics, but can close by one remark including them all: We have our work as a national Institute to do. It lies ready to our hands. It may not be easy of accomplishment but at least the effort can be made, and we have it in our power to render the Institute more influential, more representative, more helpful.

The President:—The paper appearing first on our card programme is that by Professor Elihu Thomson; but the interest in that paper is so great that it has been thought it would be better to defer it until the afternoon session when there will be a larger attendance. We have one or two papers here from members out of town which are in the Secretary's hands and which might be taken up immediately. We will therefore have the paper by Mr. E. P. Roberts, of Cheyenne, on Practical Experience with Storage Batteries, a not less important topic and one which deserves the most careful attention of the members.

The Secretary then read the paper which is as follows:

STORAGE BATTERIES IN PRACTICE.

By E. P. Roberts.

Since I had the honor of reading a paper on storage batteries at the annual meeting of 1885, we have discarded storage batteries distributed in various localities as the source of supply of current to our incandescent lamps, and have now all lamps connected with our incandescent dynamos. Having, however, a large number of cells, we have placed in position at our station about 1,200 of the same, charging them at night and using the stored current for day lighting and power, both of which are small in amount. In case of an accident to our machinery at night, we could use our storage plant to tide over the time required for repairs, or until the majority of lights could be turned off. We have not yet had a call, however, for such service, although we always have the batteries charged to a considerable extent before dark.

Since 1885, we have tried crockery and glass cells, with plates *suspended* in the same from glass rods and separated by glass rods from each other. This was a great improvement. The cells are placed on beams of a triangular cross-section, having a four-inch base, which, in turn, rest on glass insulators, Western Union pattern, screwed on pins fastened on cross pieces. The beams are first painted and then given a coat of paraffine. The insulation from cell to cell is much improved thereby. When lead cells are used they are placed on porcelain insulators on the beams, flat places being cut on the vertical angle of the beam.

I am informed, with what degree of correctness I do not know, that storage batteries have been much improved lately over those with which I have had experience, but, even if such should be the case, I should hesitate to use them where gas lighting is cheap and where it might be desired to use only a few lights in each of a large number of localities separated by considerable distances. For special cases, however, I have no doubt the storage batteries can be used advantageously, particularly when the advantages of incandescent electric lighting are considered as being of financial value.

A few of the disadvantages arising from the conditions in the first part of the above paragraph are:

1st. A large plant in each locality is needed because of possible drain on same. The ordinary use in a residence may be 15 lamp hours and the possible use 100 lamp hours. This is an extreme example, but is not exaggerated, as it was the necessary margin we had to provide, when we had storage plants in each house requiring light, for from 15 to 20 per cent. of our customers.

If several customers can be supplied from one battery plant, the margin of extra supply can be reduced. In such case it will be necessary either to connect all the customers on all the batteries connected on multiple arc, and then disconnect the batteries and charge same in series; or, if it is desired to use a meter system in which discharge bears a certain proportion to charge, an attendant must be ready to throw extra batteries on circuit needing same, and note name of customer using extra supply.

2d. A large number of plants means a number of small stations to maintain and at which to keep supplies—distilled water, acid, etc.

3d. With a number of small stations, it is difficult to regulate E. M. F. to current desires. However small the percentage of E.

M. F. lost in the discharging wires, the E. M. F. of the batteries should rise as lamps are turned on, or the lamps will be below candle-power, when a number are used, if for one or two the proper E. M. F. is used; or it will be necessary to strain the lamps when a few are used, in order to have normal brilliancy when a number are desired. To still further complicate matters, the E. M. F. is higher at the start, particularly if only a few lamps are "on," than it is later in the evening. These differences in E. M. F. are small, but are sufficient to vary the candle-power of the lamps.

If, therefore, each customer is connected with one or more batteries for his sole use the following takes place: As darkness approaches one or two lights are turned on and are raised to abnormal candle-power, straining lamps and making consumers dissatisfied with any less light later on, and as the customer's eyes become tired the light drops, possibly not below the normal candle-power, but the *comparison* is bad, and it requires considerable power of persuasion on the part of the company's "talker" and loss of his time as a "worker," to make the customer believe that his eyes are at fault and not the light. It may be that an entertainment is given in the house, and then the drop of candle-power is more noticeable, although it may not fall much below the normal.

Of course it is possible to design mechanism to overcome all such troubles, to throw in extra cells and extra batteries as required, etc. To design mechanism to accomplish such work with reliability and which will not be too costly for maintenance or prohibitory on account of excessive first cost, is considerable of a problem. Matters are further complicated by the necessary use of charging mechanism. Also, it is desirable to have switches so arranged that it will be impossible to have charging current "on" when lights are being used *from* a battery. The writer has run 1,000 lights in such a manner (with charge on) for over a year, but does not advise it from any standpoint except necessity.

If a few large stations are used, the E. M. F. at same can be readily shown at main station, and regulated from same if desired, or an attendant can be sent to any station needing regulation.

My experience teaches me that if batteries can be charged under inspection and allowed to have a discharge without excessive variation in amount of same, that the batteries will give much more reliable results than in any other way. The nearer this can be approached, the more satisfactory will be the service.

If, therefore, it seems to be advisable in any city to erect a storage battery system for general distribution, I believe it will be found best to erect a very few large battery stations at the various centres, and that the interest on the extra cost of the wire leading from the same to the lamps, over what would be necessary if each light were close to a battery, will be far more than saved in the lessening of attendance alone; and that the avoidance of other evils I have mentioned will thus be clear gain.

DISCUSSION.

THE PRESIDENT :—The paper is now open for discussion on the part of the members. Mr. Roberts's work has gone, it seems, through a considerable evolution, and has arrived at what we may term the chemistry basis. The subject was brought somewhat prominently before the National Electric Light Association at its recent meeting in Philadelphia, and I think we have more than one member present who will have some very pertinent and valuable views to express in regard to that particular development.

If I might venture to call upon any of the members, I think Mr. Mailloux is very much interested in that subject at the present time.

MR. MAILLOUX :—Mr. President and Gentlemen: I will say that it is true that I am very much interested in storage, at the same time it does not necessarily follow that I know much about it. I was very much interested in the paper prepared by Mr. Roberts, and I quite agree with him that the most promising method of employing storage in lighting large areas will be by means of a series of groups of batteries suitably located with regard to the distribution of light to a certain group and supplied from a central station. I think that it is possible to so arrange matters that we can send the energy from the central station to the various groups at a rather high potential, and then distribute it at a lower potential from these groups: in that way we shall save copper in the conductors for carrying the energy and we shall get the benefit of distribution at a low potential. In nearly all instances it is found impossible to place the charging station in the centre or equally distant from all the various groups. Usually it is found cheaper to buy land on the outskirts of a town and to establish a central station there. I know that in the case of incandescent lighting the idea of distribution by different sets of feeders has been adopted and in some cases with a marked econo my in the cost of conductors. I have in mind the case of a person interested in electric lighting—who submitted to me some data regarding an installation in some city in Pennsylvania, where he produced an economy of over twenty per cent. in the case of omnibus wires or feeders for the mains, by adopting the plan of distributing the energy in fractions to those mains, so to speak. Instead of using one set of feeders to distribute the energy to the mains; a set of feeders of large diameter; he found that he could save copper by using distinct sets of feeders of smaller diameter and striking the mains at a point more favorably situated with respect to the particular group of lamps; and in this way, having divided the total number of lamps into groups on the map of the city, he was enabled to distribute his conductors, and that is exactly what it is proposed to do with the storage battery. I do not think it is as yet the ideal system. It is far too young and full of deficiencies to compare with the systems that have been in use for four or five years, with very able men studying their deficiencies and seeking to remedy them. From what I know of the case, I think that I can quite heartily sympathize with Mr. Roberts in his tribulations—I have no doubt he had quite enough of them; but I think if he had seen some of the more improved forms of battery that are now in the market, perhaps his labors would have been materially lessened.

The President:—This point of the utilization of storage batteries in central stations was alluded to with some degree of prominence by my colleague, Mr. Wetzler, at Philadelphia, and I think that some of the figures that he then presented would be extremely pertinent on the present occasion. There also comes in, the use of storage batteries in connection with the telegraph, which I think is very important and material. We have the precedent in England; and Mr. Hamilton has given that subject, I believe, some consideration here. Mr. Wetzler might give us those figures.

Mr. Wetzler:—On the occasion that the President refers to, I brought out the fact that a company had been started at Haverford College, Pennsylvania, to run an electric light station and to have an auxiliary storage plant. The idea was this: It is conceded that the maximum number of hours for lighting probably does not exceed four or five for incandescent lighting. During the remaining time an incandescent station is practically running considerably below its capacity. Now the argument was, that if any means could be devised by which a number of engines, dynamos and boilers, could be kept running practically for twenty-four hours, there would be a great saving in cost of installation and operating expenses. The way in which that was to be overcome was by the installation of storage batteries. They have a certain number of dynamos there which they keep running, I believe, some twenty hours during the day, and during the time the current is not used directly from the dynamos it is stored in the batteries and drawn upon as occasion may require. I believe there are some 600 or 1,200 cells now in operation, and I understand, too, that the distribution to individual houses has also begun —that is having a battery in each house.

The President:—I think we would all very much like to hear Mr. Hamilton on the point to which I alluded—or Mr. Leonard, who is also a well-known telegraph man.

Mr. Hamilton:—So far I have had no experience at all with storage batteries; but I can say that the telegraph companies have considered the feasibility of using them, and while they have not arrived at a definite conclusion so far, it seems that the number of cells that will have to be provided will make the plant too costly to use. The question is still under consideration, however, as I said before, and after we have had a little experience, I may be able to say something on the subject. If we could connect the different potentials along one after the other in series, the same as we do with dynamos, it would be a very simple matter; but that seems to be impossible, because some of the batteries would be drawn upon much more than others. On the other hand if the wires are arranged in groups in such manner that those forming each group are approximately alike in resistance, and we use separate batteries to supply the different groups, then we would have to provide a large number of cells, this with the first cost and the wear and tear would make the whole cost out of all proportion. The battery does not appear to compare at all favorably with the dynamo. Possibly within the coming year we may be able to tell something definite in regard to it, because it is possible we shall use a few of the cells. I do not know what the experience has been in England, but I think they have only used the the battery to a limited extent there.

The Secretary:—In conversation with Mr. Hamilton, I understood that one of the reasons why the dynamos were not more generally adopted for furnishing current at the large telegraph centres was, because there were very few places where the demand for the current was sufficient to warrant the running of the plant for twenty-four hours continuously; nor when this was done could sufficient economy be gained to make it worth while to change from the primary battery ordinarily in use to the dynamo. I would like to inquire from Mr. Hamilton, in connection with this, whether it would not be possible with the use of storage batteries to utilize the dynamos in centres where it is not now economical to run them for twenty-four hours continuously.

Mr. Hamilton:—I do not know that I get the gentleman's idea.

The Secretary:—In Pittsburgh, for instance, I understand you are about putting a dynamo plant there.

Mr. Hamilton:—Yes; within the coming three months the plant will be put in there. Wherever we have from 9,000 to 10,000 cells I think it would be advisable to put in a dynamo plant. But I doubt very much whether we could do anything with a storage battery, because we must have four or five different potentials at least. This must be duplicated to get opposite polarity to line; which would be ten different batteries at once, and then you have got to include a spare afterwards, which at $17.00 or $18.00 or $20.00 a cell is rather expensive.

The Secretary:—That would be a very suitable problem for Mr. Mailloux to grapple with.

Mr. Frank L. Pope:—There is another application of the storage battery which has not been discussed at this meeting, respecting which I would like to say a few words of possible interest to the members.

A short time since I was applied to by the president of a street railway company, in one of our largest cities, which is about to build a new line about five miles in length, on which it is proposed to run something like twenty cars. The gentleman came to consult me about the possibility of working the line by electricity, stating at the same time that there were insuperable objections to the use of any sort of overhead conductors, and that very serious opposition would be made to the use of a conduit or anything which would occasion the slightest disarrangement of the pavement. He therefore wished me to investigate the question of running cars by accumulators or storage batteries. In undertaking such an investigation, I examined a car which was being experimentally run on the Eighth Avenue in this city with the

Julien accumulator, by the Julien Electric Company. I was very much more favorably impressed with the results attained than I had anticipated, although it was easy to see that much better work could be done by the system than was being done there. In the first place, of all the street railway lines in New York city the Eighth Avenue is perhaps the most miserable in its construction. Its track would hardly be tolerated on a contractor's dirt road out in the country; and yet the street railroad people in New York, who are using the most costly form of energy in the world—horse power—are wasting from half to two-thirds of it in battering their tracks and their cars to pieces against each other. There appears to be an opportunity for a good deal of missionary work in that direction, on the part of our sister society, the Civil Engineers.

To return to my subject, I made a careful investigation of the matter and procured some accumulators and had them put under test by one of our most careful and accomplished young electricians, and from the results obtained by him I became entirely convinced of the practicability of operating street cars at a cost something less than by horse power at all events, and possibly considerably less. It is difficult to arrive theoretically at the cost, because no one seems to know exactly the average power required to propel a street car. The load varies greatly at different times of the day and the resistance or traction varies widely according to the condition of the dirt on the track, whether wet or dry, and how much there is of it, so that nothing short of a series of practical experiments will give us exact results. We were, however, sufficiently encouraged to go on and have a car built, embodying all the modern improvements, with excellent running gear and highly efficient motors, and that car, I suppose will be ready for operation within two or three months. We intend to put the car into actual service, to carry passengers with it the same as the horse cars, and meanwhile to carefully observe the value of current used and of power consumed and to gather all the information we can, which will be available for general use when we get through.

I might add that our theoretical investigations indicate that with a number of cells, which can easily be put under the seats of an ordinary 16-foot street car, we may expect to run such a car something like fifty miles with one charge of the battery. This will enable us to do a full day's work of 16 to 18 hours by changing the batteries once. I shall be very glad to report the results of the experiment at some future meeting. [Applause.]

Mr. Mailloux:—I would like to merely make a word of comment on the remarks of our esteemed ex-President. I would submit that he could not run fifty miles with every kind of battery that is being introduced, and I think it would be better to say that with some forms of battery he could run fifty miles. There are batteries with which he could not run twenty-five miles.

The President:—I presume it is understood we are speaking of the most advanced appliances.

Mr. Frank L. Pope:—I suppose one of the reasons why they employed a professional person to investigate the matter was in order that they might not get a battery that would run only twenty-five miles.

Mr. Edward P. Thompson:—The success of a scheme often depends not only upon the device itself, but upon the man who has the device in charge. Perhaps no man is better acquainted with Mr. Roberts than I am, having roomed with him about three years at the Stevens Institute and worked with him in the laboratory one year. After graduating from the Institute, he took the position of an ordinary mechanic for the purpose of thoroughly learning the machinist's trade, at the tool room in the Singer factory. I happened to work there also at one time for instruction, and the men engaged there told me that they each paid a hundred dollars to learn their trade, so as to be employed at the Singer factory, whereas Mr. Roberts not only learned the trade, but was paid by the week. Further, he went to a factory for the manufacture of hats, in Newark, where he was foreman and general manager and obtained considerable experience; fitting himself in that way for the practical application of his knowledge of mechanics. He was appointed as electrical mathematician by the United States Company, the success of which is probably greatly due to his designs of dynamos and other machinery and lamps. At the Swan laboratory he was well known as a man who worked from eight o'clock in the morning to twelve at night. I learn from Cheyenne, that he has been working for a long time, for eighteen hours a day. Having all this experience, and knowing also that Cheyenne is the place where an attempt has been made to run the electric light by storage batteries, and knowing that Mr. Roberts has had such experience, seems to prove that in this case the failure was not due to the man. Mr. Roberts is also an inventor, and he has probably been able to make up for defects in any details of construction, and in that way further insuring the success of the storage system.

THE PRESIDENT:—I was very glad to hear Mr. Thompson speak so highly of Mr. Roberts, and I think that Mr. Roberts deserves our hearty sympathy and consideration for his frankness in speaking on these topics and for the readiness with which at a distance, such as that of Cheyenne, he sends us papers and brings his work to our notice and looks to us for encouragement and information with which to develop his work in the future.

MR. THOMPSON:—I would add that Mr. Roberts was regarded by the Brush-Swan Company as the best man they knew of in the United Sates to take charge of the works at Cheyenne. He was paid a reasonable salary, and I know personally that they looked around for a great many men and tried several before they succeeded in obtaining just the man they wanted in Mr. Roberts.

THE PRESIDENT:—The next paper on the programme will be one by Prof. W. A. Anthony, of Cornell, on the Differing Temperature Coefficients of the Different Coils of a fine Rheostat.

ON THE DIFFERING TEMPERATURE COEFFICIENTS OF THE DIFFERENT COILS OF A FINE RHEOSTAT.

BY PROFESSOR W. A. ANTHONY.

The title of this paper should rather have been "A Description of Experiments by which the Differing Temperature Coefficients of the Coils of a Fine Rheostat were Discovered." I thought the experiments of sufficient interest to warrant a description, and I find, on writing the paper, that the experiments occupy the greater part of it.

In 1884, the Cornell University ordered of Latimer Clark, Muirhead and Co., of London, a fine rheostat and bridge of special construction. Among other things it was specified that the resistances of the coils of both bridge and rheostat should check among themselves to 1-100th of one per cent., and that everything should be done to make the instrument as accurate and reliable as it was possible for such an instrument to be. On its arrival it was found not to fulfill the requirements as regards accuracy, the coils differing among themselves in many cases by more than 1-10th of one per cent. It was returned to the makers for readjustment and did not come back to the University for several months. On its return it was found that the adjustment had been much improved, but still did not come within 1-100th of one per cent. It was, however, finally accepted at a reduced price, the writer proposing himself to perfect the adjustment.

Press of other work prevented this being done, and, last November, when a problem requiring the highest attainable accuracy in the comparison of two resistances presented itself for solution, this rheostat was used for making the comparison, it being proposed to afterward determine and apply the corrections for the errors of the individual coils.

The problem was, to find by experiment the ratio of the constants of the suspended and stationary coils of the large galvanometer, a description of which has already been read before the Institute. The constants of these coils were determined by measurement while they were being wound and the experimental determination of the ratio was undertaken as a check on the measurements. To determine this ratio, a current is made to divide between the stationary coils on the one hand, and the suspended coil on the other, but in the reverse direction, so that the two currents shall have a differential effect on the needle. The resistances are then adjusted till the needle is unaffected when the cur rent in both branches is reversed. The constants of the coils in the two branches are then directly proportional to the currents flowing, and, therefore, inversely proportional to the resistances of the two circuits.

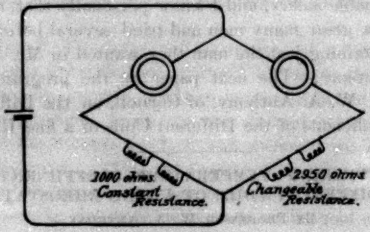

Figure 1.

To obtain the ratio of these resistances, they were arranged as two branches of a Wheatstone's bridge, as shown in figure 1, the other two branches being made up from the rheostat referred to above. The apparatus was arranged and the tests made by Mr. Ryan, a senior in electrical engineering, and Mr. Hammon, a graduate student of electrical science.

The first trials showed that nothing could be done with binding-screw connections and sliding contacts. All permanent connections were therefore soldered, and all others made with mercury. After this was done, irregularities still existed which were traced to varying temperatures, resulting from the fact that the building in which the galvanometer is mounted is of wood and warmed by a wood fire in an "air-tight" stove. The fire was allowed to go out, and the work continued at the temperature existing outside, about zero centigrade. Times for the experiment were chosen when the temperature was quite uniform, and the results were found to agree very well among themselves, but, to our surprise, they were totally different from the results obtained at the higher temperatures. The table below will show how the results ran.

Room warmed			No fire in room.	
Temp.	Ratio.		Temp.	Ratio.
21.4	2.9520	Dec. 7	1.7	2.9492
21.3	2.9523		1.7	2.9492
20.8	2.9529		1.8	2.9492
20.3	2.9524		1.6	2.9492
20.2	2.9526	Dec. 8	3.7	2.9495
20.2	2.9528		3.8	2.9498
19.1	2.9529		3.8	2.9497
			3.8	2.9497
			etc.	etc.

Here is a difference of one-tenth per cent. for a change of temperature of about 20 degrees centigrade. It should have been stated that the ratios above are the ratios of the two resistances as read from the rheostat; that one of the resistances was always 1,000, and of the other, which was nearly 3,000, only the units and tenths coils were changed.

A study of the construction of the galvanometer, and a discussion of the effects of temperature upon it, made it clear that the change indicated above could not be a real change in the ratio of the constants of the coils. It must, therefore, be looked for in the rheostat. To test this conclusion, different sets of rheostat coils were used in making up the arms of the balance, and tried at high and low temperatures. In one case the ratio was apparently larger at the lower temperature, the reverse of the result shown in the tables above. But the crucial test was suggested and tried by Mr. Ryan. He took the rheostat out of doors and then subjected the galvanometer and all accessory apparatus, except the rheostat, to changes of temperature. The rheostat then indicated the same apparent ratio for all temperatures of the galvanometer.

It is certain, therefore, that a change of temperature of 20 degrees causes a change in the relative resistances of two sets of coils in this rheostat to the extent of 1-10th of one per cent.; that is, the temperature coefficients of the different coils are not the same, and it is, therefore, no wonder that the makers could not adjust the resistances more accurately. Such differences of temperature coefficients might well occur if the wire of which the coils are wound was taken haphazard from different lots, made perhaps, from different lots of metal. If makers of fine instruments are not careful to select wire that is sure to of be one composition for the construction of resistance coils, it is no wonder that it is so difficult to attain to a high standard of accuracy in electrical measurements.

But there is another possible explanation for the differences found in this instrument. The low resistances are of coarse wire, and this, from different temper or from different treatment in drawing, might not have the same coefficient., although made from the same metal, as the fine wire. In short, I believe that, for the construction of an accurate rheostat, the coils should not only be from the same lot of metal, but should all be drawn to the same size and subjected to the same treatment while being drawn. The wire chosen should be fine enough for the coils of highest resistance, and coils of low resistance should be made by winding two or more of the same wires in multiple arc.

DISCUSSION.

Mr. Wallace:—What is the size of the wire?

Professor Anthony:—We never have measured the wire, it is all covererd with paraffine.

Mr. Frank L. Pope:—I would like to ask if Professor Anthony knows of any experiments with American made wire, and whether the same discrepancy is observable there.

Professor Anthony:—I do not know of any such experiments. It is our purpose to make an investigation of this sort; but this is all I have to report in regard to the matter at present.

The Secretary:—I think Mr. Prescott is here. We should be glad to hear from him.

Mr. Geo. B. Prescott, Jr.:—Professor Anthony states that the wire in this rheostat was of different sizes. Now, if the current passing through this wire was of the same strength in all the different coils the tendency would be to heat the thin coils more than the thick coils, and I suppose that would need to be eliminated.

Professor Anthony:—In regard to that, the current was not sufficient to heat the coils any way. I suppose the current would not have heated the coils 1-100 of a degree.

Mr. Schuyler S. Wheeler:—The kind of current that can be used with a reflecting galvanometer is about a thousand times removed from the current that would heat the wire.

The President:—It struck me that Mr. Prescott asked a very pertinent question. Could Mr. Prescott give us any definite, positive information from his own work?

Mr. Prescott:—Some two or three years ago, Mr. Weston, with whom I am engaged, was making some fine measuring apparatus and he found very great difficulty in getting german silver wire at different times that was of a uniform quality. For that purpose, he made some experiments on his own account, to determine the nature of this variation and what caused it. What led to his immediately taking up the subject was a paper published a short time previously in England by Professor Bottomly, who reported the discovery, by Mr. F. W. Martins, of a new alloy which he called platinoid. He said this alloy was ordinary german silver, with one or two per cent. of tungsten added. He showed by some tests that its specific resistance was very much higher and its temperature coefficient very much smaller than german silver. I looked at his original paper and I could not find what the proportions of the german silver alloy were. I had searched through all the works previously to this on that subject that I could find, and not one of them gave the proportions of this german silver alloy, not even Matthiessen. For instance, you will find in the ordinary tables in the text-books a list of the different alloys, in which the proportions of each one are given, until you come to german silver, and there they say german silver, plain and simple, as if every one knew its proportions. In this country, I went to several of the makers of wire and asked for their proportions and they seemed to use almost everything. After Mr. Weston had heard of this alloy of tungsten, he thought he would investigate it. He made up some ordinary german silver and put some tungsten into it and kept on adding it, until he got ten per cent., and he found that it did not make any difference. But he found, by varying the proportion of the nickel, that the resistance could be made almost anything, and that the resistance of german silver is almost directly proportionate to the amount of nickel. The effect of zinc was only that of dilution, but it had a mechanical advantage in making the alloy ductile, so that it could be more easily worked. We also found that the temperature coefficient varied in the same manner, and that the greater the amount of nickel in the alloy, the smaller would be the temperature coefficient. We got results very much higher than had been obtained in England with this alloy called platinoid, which was undoubtedly a german silver alloy with a high percentage of nickel. The temperature coefficient of this high resistance alloy we endeavored to determine, but we met a difficulty with this: We had a bridge—the largest pattern made by Elliott—of very large wire and very few contacts. It is called the dial pattern, in which there is only one contact for a series of plugs. We tried to get the temperature of the room very even and we obtained some very curious results, for we found that the temperature coefficient was sometimes in the reverse direction. It decreased apparently after a certain point. But as we never could be certain of the true temperature coefficient of our bridge, we were compelled to abandon determining what the exact coefficient of the wire was; and that question of the increase of nickel increasing the resistance and decreasing the temperature coefficient we proved beyond doubt.

Mr. Mailloux:—I think it would be of interest to have Mr. Prescott state what is the largest specific resistance he obtained with various proportions of nickel.

Mr. Prescott:—In the Western Union Telegraph Company, the electricians have a peculiar way of giving specific resistances. It is a very large unit easily understood and it is termed the mile ohm. It is the weight of a wire a mile long, which will give just one ohm resistance. The ordinary german silver on the market has a specific resistance of 12,000 pounds to the mile ohm; that is to say, a wire a mile long having one ohm resistance requires 12,000 pounds of metal. We found, by using an alloy of something higher than thirty per cent. of nickel, that we got a mile ohm of 38,000 pounds, something more than three times the specific resistance of the ordinary german silver on the market. The temperature coefficient, as I said before, was so small that we could not, with the apparatus that we had, determine whether there was none at all, or whether it was in the reverse direction.

The President:—I think this is an extremely important topic and it would hardly be fair to dismiss it without having the views and opinion of the members more fully brought out. We have with us one or two gentlemen, who have some very valuable information to contribute to the purposes we are here for, which is to increase each other's fund of information. Mr. Wallace could give us some very interesting data on the subject of this wire. It is as Mr. Pope has already pointed out, somewhat significant that we are discussing an English instrument. I was very much struck by a fact which came under my notice last week, where in a city in this country of 400,000 people, an electrician doing a piece of new work was absolutely unable to obtain any number 9 iron wire and, in order to introduce resistance, took the hoops off some hay bales and used them for that purpose.

We have with us also Mr. Carl Hering, who has done, I believe, some very interesting work in that direction, and from either of these gentlemen we should be very glad to have remarks.

Mr. Wallace:—Speaking of german silver, there are all sorts of mixtures on the market, and it does not surprise me at all that you do not get two samples alike. There is another thing: You can take the same mixture and pour it at different heats and get different results from exactly the same mixture. Then you may roll it too much or you may draw it too much, and if you do not anneal it sufficiently, you can pull it apart and you will get all sorts of resistances in that way. German silver is a very uncertain metal to handle. I have made a great many tons of it and it is very difficult to get two batches alike.

Mr. Hering:—I am sorry I cannot contribute to the general information on the subject. I have had very little experience with german silver other than in measuring instruments.

Mr. J. A. Powers:—I can speak very feelingly on the subject of the quality of german silver wire in the construction of the McDonald cut-outs, if you will allow me to be somewhat personal. I find that it is impossible for us to get wire that will wind twice alike. We wind it up in bands and with a certain definite number of layers. We are obliged to adhere rigidly to a certain routine, in order to produce certain results, and all coils are wound up and measured at the same time; and we find that doing the best we can, we will have more or less variations of the wire. We have been to many different manufacturers for our wire and have been very careful about the gauge, and more careful about the temper, but it still bothers us all the time to get wire perfectly uniform.

Mr. Mailloux:—I can add an item of my own experience on the subject. Very recently I had occasion to use some resistance coils, made for an electrical railroad signal system, and the manufacturer showed me two bobbins that he had wound; I think that it was intended to use a resistance of twenty ohms and he was to use No. 18 wire to wind it. He showed me a bobbin which was wound with that resistance, and another one on which he said he had to take a No. 20 wire in order to get the resistance, and then he could not get it. He wound it until the bobbin was full with No. 20 wire, and even then could not get the required resistance. I have no doubt there must have been twice the weight of wire, and of a much finer size than on the other bobbin, and yet he did not have the necessary twenty ohms. That would show the great difference of specific resistance of the various samples of german silver as we find them in the market; and it would be very desirable to have researches prosecuted on the subject, so as to have some definite understanding arrived at, which would guide manufacturers in the making of german silver of a standard resistance. It is of the utmost importance to us as practical men to be reasonably certain of the grade of wire we are using. In a great many instances I find that I have a limited space in which to put a given resistance; and if the wire is not right as in this case, it becomes a matter of great difficulty to accomplish the result sought for. I would like to have Mr. Prescott state for our information, and give it as a matter of record, whether he advises the construction of rheostats for measuring purposes, made of wire, having such a high resistance; and also whether such wire can be had in the market.

Mr. Prescott:—I would say the higher the specific resistance and the lower the temperature coefficient the better adapted the wire is for use in rheostats. The wire can be handled and is not too brittle. All the wire that I have used has come from the Coe Brass Company, who make it according to specifications.

Capt. Michaelis:—I cannot contribute anything to the knowledge of the subject, in the way of any special investigation pertaining to the matter under discussion. But I would like to call the attention of the Institute to something that has struck me in this discussion which may have a bearing on this matter and which shows the interdependence of all these investigations. The question of the wire winding of guns has been a very important one in the last ten or fifteen years, and the subject of the winding tension of the wire has a very important part to play in the amount of pressure brought to bear upon the core. It appears to me that in winding these coils spoken of, this fact should be taken into consideration; for no matter how small a winding tension we may have, when the very small cross-section of the wire is considered, even if it be but an ounce, but increasing directly with the area of the cross-section of the wire, you will find when you come to square inches that you have very large winding tensions to deal with. Now, in a wire wound gun, which is after all nothing but a large bobbin, we have to take into consideration the resulting pressure due to successive layers. A tube is the base of the gun, and the initial pressure on that tube is calculated; but that pressure increases constantly with the number of windings on it. In this investigation of the amount of pressure, we use the ordinary formula in regard to a cylinder, subjected to a uniform fluid pressure where the pressure produced at any point—if I recollect right—is equal to the thrust divided by the radius. Now, say you have wound the coil to a certain radius, your successive wires that are brought around it will exert, entirely as a result of the winding tension, a definitive amount of pressure on the layers that are already there. In other words, suppose you wound your bobbin one-half, you can consider that half-wound bobbin as a new core, which will be compressed, which will be subjected to a very high pressure, merely as a result of the winding tension of the wire; and I would like to ask some of the learned gentlemen who have given this matter consideration, whether the effect of that winding tension in producing pressure, and of course consequently changing the mechanical condition of the wire, has been considered in these investigations.

Mr. Mailloux:—I would submit that in the winding of fine wires the tension is usually made as slight as is consistent with the proper guidance of the wire in winding. In winding larger wires—dynamos for instance—a great deal of tension is placed upon the wire, and I have seen in practice the effects of that tension, where by lack of precaution in insulating the core before winding, the inner layer of the wire had become abraded, and sometimes short-circuited with the core—the result of the pressure which follows the superposition of the various layers. I do not think that the tension would figure in small coils, though I think it might have some influence in large wires; but as the increment or decrement of resistance would be so slight it would probably be neglected in dynamo machinery and other machinery where large wire is used.

Mr. Hamilton :—I might say in respect to Capt. Michaelis's remarks, that a report was published in the Philosophical Magazine three or four years ago, where the writer had taken quite a number of different wires and measured their resistances both before and after winding, and the differences were quite considerable. I have recognized for a long time, this point of temperature coefficient for the wire, and a number of years ago, in ordering wires for coils, I specified that the wires should be of the same quality all the way through, so I should be sure of the temperature coefficient. I also think the suggestion of Professor Anthony, that the wires should be drawn of the same size, is a very good one as is also the winding of the same in multiple arc when they are used for the lower coils or liable to have heavy currents sent through them.

Prof. Anthony :—There has been a good deal said in regard to the difference in different batches of german silver, and in regard to difference in temperature coefficient. We know that the temperature coefficient would vary considerably in different batches. If the resistance coils I was describing, were made from different batches of german silver, I should expect the results to be as I found them—in fact very much more variable than I found them. But if reliable makers manufacture standard instruments, such as this is, from different batches of german silver, it is a very reprehensible practice. I supposed that care would be taken to select wires which had been drawn from the same batch of metal. I do not believe, with all the care taken in the mixing of german silver, that you could get two batches that would give the same result for the temperature coefficient, and for that reason I should suppose that, in making such an instrument as this, it would be necessary to take the german silver from the same batch, and not from two batches supposed to be exactly alike. The point I wanted to make was that, as coarse wires and fine wires drawn out of the same batch may not have the same temperature coefficient, because of difference in annealing and temper; and that must be guarded against as well as difference in composition due to accidental variations. Possibly also in the annealing process, since a fine wire would have to be annealed several times over, while a coarse wire might not have to be annealed at all, a change in the proportion of the constituents might occur from oxydation of one of the metals to a greater extent than the other.

So my suggestion was that it would be important in making fine instruments of this sort, not only to use German silver from the same batch, but to take all of the wire from the same lot and of the same size, that had been drawn at the same time, and subjected to the same pressure throughout, from the time the metal was melted until it was finally drawn in wire and covered and wound upon the coil, and then to use several of those wires in multiple arc for the coils of low resistance.

Professor Thomson:—It occurs to me that this point might be touched—whether in winding a large wire there is not more mechanical energy expended, and a hardening or change of the molecules of the large wire, since it is wound on the same diameter as the smaller wire in making the coil. We will assume that we have a wire of a certain diameter and compare it with a wire of much smaller diameter. Now, in going around a certain arc, the metal on the half of the wire towards the centre will be compressed, while that on the exterior will be expanded, and the amount of compression and expansion, with a certain radius of winding, will be of course much greater in a coarse coil than in a coil of fine wire. This may have some bearing perhaps on the point under discussion.

Mr. Mailloux:—With regard to the remarks made by Mr. Hamilton, about the resistance of wire before winding and after winding, I think that it is due precisely to the point mentioned by Professor Thomson, and I was going to speak of it before; but I am glad that I waited until Professor Thomson had mentioned his point, because I believe it is the explanation. I have myself noticed (altogether I have not the resources of a physical laboratory at my command) that a wire that has been wound and unwound several times has a difference in resistance, especially if it is in considerable lengths, and I thought at first that I was mistaken; but with very careful measurement I found that there was a slight difference between the two; and I cannot find it to be due to any other cause than some molecular disturbance in the wire, or possibly a slight amount of stretching.

Professor Thomson:—Take a piece of metal and bend it on edge, and then bend it on flat, and it seems to me by that means we would arrive at the fact or not of there being a change of resistance produced by bending flatwise and on edge.

The President:—We have some other important papers on the programme. The next which we shall take up will be that by Mr. Dugald C. Jackson, of Cornell University, on the best Ratio of the Section of a Gramme Armature to the Section of the Field Magnets.

Mr. Jackson read the following paper:

THE RELATION BETWEEN THE CROSS SECTION OF THE IRON IN ARMATURE AND FIELD OF THE GRAMME DYNAMO.

BY DUGALD C. JACKSON.

The relation between the cross section of iron in the armature core to that in the magnet limbs in a dynamo machine is an important one. On its proper adjustment, in an otherwise well-designed machine, depends the attainment of maximum efficient output per pound of wire with minimum of iron. Of two machines, designed for a given purpose, the one with a Siemens armature and the other with a Gramme ring, the path of the lines of force through the armature of the latter machine will usually be considerably longer than in that of the other. It is evident that special care should be exercised to make the Gramme armature of sufficient area of cross section, that its magnetic resistance be not increased unduly. Siemens armatures, from mechanical principles, call for a goodly amount of iron; while an increase of cross section in a Gramme armature increases mechanical difficulties considerably. Consequently Gramme armatures usually have considerably smaller cross-section than Siemens armatures, in machines intended for a similar use, magnetic conductivity being sacrificed for mechanical convenience in the Gramme. How far this sacrifice may be carried, without impairing the value of the machine, must of necessity be specially determined for each individual case.

The question of how far the characteristic, and so the output of a machine, is influenced by variations in the cross section of the armature could be determined by Hopkinson's very beautiful method of predetermining characteristics. In a machine, the outline and dimensions of which are determined by conditions imposed, the curves of magnetization, such as Dr. Hopkinson used, would be fixed for the field and air space. By plotting curves for armatures of various cross-sections, the area giving the best characteristic, and yet not unduly decreasing the internal diameter of the ring would be evident. The value of the leakage ratio v, might be estimated by Prof. George Forbes's method, if the shape of the diagrams were not too complicated.

An experimental solution of the problem for a little dynamo was made this term in the Physical Laboratory at Cornell University. If we had armatures for one dynamo made with cores of various cross-sections, the best section would be apparent from the characteristics. However, it is not necessary to wind the armatures, but simply to measure the number of lines of force passing through the armature for various magnetizing forces—that is, observing the data for a curve of magnetization. This may be done in several ways.

In the experiment referred to, a single turn of wire was placed around the section of the armature core perpendicular to the directions of the lines of force. This was connected with a ballistic galvanometer. The swing of the needle of the galvanometer was observed when the current was reversed in the magnetizing coils on the field. The swing was thus proportional to $2HA$; A being the area of the turn of wire, and H the induction per unit area. Knowing the magnetizing current and the corresponding swing for a number of points for each of several different armatures, the corresponding curve of magnetization may be plotted. These curves are exactly similar to the total characteristic of a series dynamo or the internal characteristic of a shunt machine.

The field of the little dynamo experimented upon is of the single horseshoe type standing upon the yoke. This is rectangular in cross section. The limbs are cylindrical and are held in place on the yoke with two pins each, the contact surfaces being perfectly plane. The yoke and limbs are of the best Norway iron. The pole pieces are of a very good quality of cast-iron and are chambered to fit the upper ends of the limbs, which enter for a length of 7 cm., making the area of contact considerably greater than the cross-section of the limbs. The cross-section of the pole pieces is much greater than that of the limbs. The bore of the pole pieces is 10.8 cm. in diameter, there being a gap at the top and bottom subtending an angle at the centre of the bore of 51 deg. The width of the surfaces on either side of the gap is .3 cm. The corners of the pole pieces are all rounded off.

Following are the dimensions:

Limbs (cylindrical).

Length	20.3	cm.
Diameter	6.35	"
Area of cross section	31.66 sq.	"
Distance apart from centre to centre	17.9	"

Yoke (rectangular).

Length	26.8 cm.
Width	8.2 "
Depth	6.9 "
Area of cross section	56.6 sq. "

Pole pieces.

Height	10.2 cm.
Width	10.2 "
Bore	10.8 "
Mean area of cross section	—— sq. "

The magnetizing coils consist of 785 turns on each limb, making a total of 1,570 turns.

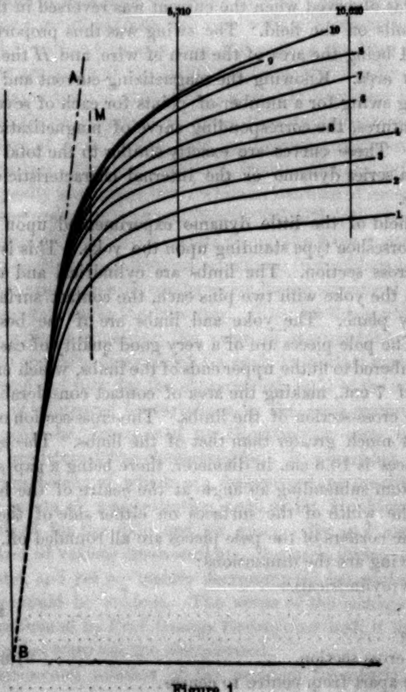

Figure 1.

The armatures were composed of thin punched discs of soft wrought-iron obtained through the courtesy of Thos. Pray, Jr., of Hartford, Conn. The discs were insulated by dipping them into shellac varnish and then built into armatures by placing them on wooden mandrels turned to fit their internal diameter. The variation in the cross-section of the armatures was obtained chiefly by using armatures of the same number of discs, but of different internal diameters. As it was not possible to secure discs with the proper internal diameters to give all the area desired, some of the armatures were composed of fewer discs. In these, thin spaces were left between the discs, and the area inclosed by the exploring coil was slightly greater than that of the iron. The effect of this has been neglected as too small to be appreciable. The areas were obtained by multiplying the thickness of the discs, which was .0462 cm., by the number on the armature.

The magnetizing current was furnished by a number of storage cells. In the circuit of these were placed a tangent galvanometer and the magnetizing coils. A reversing key was so placed in the circuit as to simultaneously reverse the current in the galvanometer and coils. The magnetic induction was measured by a ballistic galvanometer, as already explained. The observations were taken by Mr. F. R. Jones, an engineering student working in the laboratory. The regularity of the curves attest the care with which he carried out the work. I have here a sketch, figure 1, of the curves determined by Mr. Jones, which, I think you will agree with me, are very interesting.

The following table gives the areas of the cross section of the armatures and their ratios to the cross section of the magnet limbs:

Armature	No.	1	17.75	Cm.	Ratio	0.561
"	"	2	19.23	"	"	0.607
"	"	3	20.70	"	"	0.654
"	"	4	22.19	"	"	0.701
"	"	5	23.66	"	"	0.747
"	"	6	25.14	"	"	0.794
"	"	7	27.36	"	"	0.864
"	"	8	29.18	"	"	0.922
"	"	9	34.49	"	"	1.09
"	"	10	42.44	"	"	1.34

In curve No. 1, where the armature has little more than half the area of the limb, the turn in the characteristic is sharp and the straight line representing the upper portion of the curve is almost horizontal. The rapid and great increase of magnetic resistance shown by the curve to the right of the line *M* must be due entirely to the saturization of the armature. As the area of the armature increases, the turn in the corresponding characteristics grows into a longer sweep and the upper part of the curve takes an increasing angle with the horizontal. Curves Nos. 9 and 10 are given by armatures greater in cross section than the limb, and though there is a difference in their areas equal to a quarter of the area of the limbs, there is very little difference in the total induction passing through the armature. The curve No. 10 then probably very nearly represents the curve of magnetization of the iron in the field and the air space. The straight line, which constitutes the lower part of the characteristic, being the backbone of the curve, as it were, must very nearly represent the line of magnetic resistance of the air space. By air space I mean the space between the pole piece and armature.

Looking at the curves there, you see the armature No. 1 was highly saturated, or, in other words, had become of enormous magnetic resistance before the permeability of the field began to decrease appreciably. On the other hand, armature No. 9 has increased in magnetic resistance very little up to the point to which the characteristic has been carried, while the field is quite saturated. Between these extremes there are varying degrees of relative saturization of the armature. In curve No. 7, the field and armature are apparently at about equal degrees of saturization throughout. The curve (shown in Fig. 2) illustrates the effect on the total

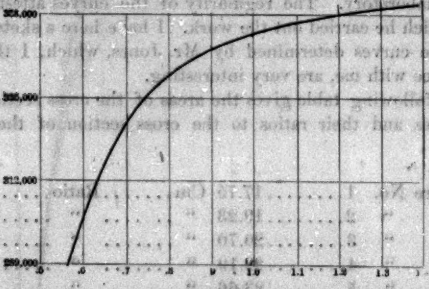

Figure 2.

induction through the armature, of the ratio of the area of the armature to that of the limbs. As ordinates are plotted total induction through the armatures taken from the characteristics on the section line *M*. The abscissas are ratios of the cross-section of the armature to that of the limbs.

This curve is exaggerated in vertical scale, so that its character may be more plainly seen. It shows obviously that the induction through the armature increased quite rapidly when the armature core was increased in area from .5 of that of the magnet limbs to about .75 that of the limbs. From .75 to .9 there is still an increase of armature core, though not so good as before, and beyond .9 the increase is of no practical importance.

If the section at *M*, Fig. 1, had been taken farther up the curves, the relative increase of total induction with increase in the area of the larger armature would not have been so marked.

The section at *M* is taken at 2,660 ampère turns; that is, an absolute magnetizing force of 33,420. The absolute total inductions for this magneto-motive force are shown in the curve, Fig. 2. These were determined by comparing the throw of the ballistic galvanometer given by the armature with that given by a standard coil turned through 180 degrees in the horizontal component of the earth's field. The value of the horizontal component at the place of the standard coil was determined by comparison with that in our magnetic observatory by the use of the compensated magnetometer.

We may safely assume that the cross-section of the armature should be about .75 of the cross-section of the limbs if the wire on the armature is to have the greatest activity without an excessive quantity of iron in the core. By making the cross-section of the armature .6 of that of the limbs, a loss of 10 per cent. of the total induction, when the ratio is .75, would be made, and consequently an equal loss in E. M. F. and the output of the machine. This is a case where the permeability of the field magnet is equal, or very nearly equal to that of the armature. If the permeability of the armature core were greater than that of the field, the area of armature could be a smaller ratio.

No allowance has been made in this for the effect of a current in the armature. That should at any rate be small, except in the case of arc-lighting machines, where a great number of turns of wire are placed on the armature with the purpose of gaining stability in the light.

The absolute intensity of the magnetic flow per square cm. in the armature was quite high. In armature No. .5, the section of which is practically .75 that of the limbs, an induction of 14,000 per square cm. was given by 2,666 ampère turns. For about 10,000 ampère turns the induction was 17,000 per square cm, 10,000 ampère turns gave an induction of 11,000 per square cm. through armature No. 10, and about 18,000 in armature No. 1. The latter was increased to nearly 19,000 by 12,500 ampère turns.

The induction per square cm. corresponding to the best conditions in this machine is 14,000 per square cm. This is high for a dynamo. I believe Dr. Hopkinson has placed the figure in the Edison-Hopkinson machine as 8,000, and if true, this is probably seldom exceeded. I am aware that the value apparently reached 20,000 in the Manchester dynamo in Hopkinson's late tests, but that high value cannot be given much weight, even though the armature was pretty well saturated. I may be placing the limit entirely too low, as I have a number of records where from 10,000 to 15,000 is claimed, but simple claims are endowed with great uncertainty.

It may be interesting to note the ratio of the areas in two or three dynamos of ordinary size. It is impossible to estimate the area of iron in an armature with wire on it, because of the uncertainty in the space occupied by insulating material between the iron discs. In the record of their late tests, the Hopkinson's have given the areas of the armature and magnet limbs in the Edison-Hopkinson and the Manchester dynamos. In the Edison-Hopkinson machine, the field had probably nearly the same permeability as that of the armature core. The cross-section of the armature was about .8 that of the field and the field was considerably more saturated than the armature. In the Manchester dynamo the field probably had a lower permeability than the armature, and they were about equally saturated. The cross-sections of the Gramme ring in this machine was about .6 that of the cross-section of the field.

DISCUSSION.

The President:—The paper is now before you for discussion. It seems to me that Mr. Jackson has thrown down two or three gauntlets that some of you should be in a position to pick up. Mr. Wheeler has done some very important work in this direction.

MR WHEELER:—All I can say in discussing the subject is that the paper deserves the most unlimited praise. I will admit frankly that I did not expect it would, but having heard it I cannot say too much in favor of it. I think the paper is nearly perfection. I shall have to study over some of the points. I have arrived at some of the conclusions which are expressed in the diagrams, not exactly by different sources of reasoning, but by different tests; for instance using a Prony brake screwed up tight to the pulley, and an ordinary spring scale to show the pull. The pull at the periphery of the dynamo pully is the equivalent of the electromotive force; in fact in the early stages of their dynamo work some gentlemen whom I know made their electromotive force calculations entirely by the pull.

That second curve on the diagram is extremely interesting and extremely valuable. I understand, without having had enough time to digest thoroughly the important points stated, that that curve represents the effect of making changes in the cross-section of the armature; that is to say as you go to the right hand in the curve the short perpendicular line represents increase in the section of the armature core, compared with the field, and the distance up and down represents (to speak very practically) the benefit derived. The result of the work of my friends and of myself has been that we have pitched our machine at exactly the point marked .75 of the diagram. There is no line drawn there but it is exactly at that point. We have done this after carefully studying the subject and weighing the consideration. The effect of making the section of the armature less than 75 per cent. of the section of the field magnet would be to reduce the capacity of the armature for carrying the lines of force across the field, more than we would gain armature wire space; and the effect of increasing the proportion of cross-section would be to reduce the wire space too much, so that we have found 75 per cent. to be the best proportion as Mr. Jackson points out.

The upper set of curves are also very valuable indeed, showing the actual performance of armatures of different proportions and I have listened to Mr. Jackson's paper with a great deal of interest and benefit.

PROF. THOMSON:—The subject of dynamo designing is undoubtedly one of very great importance and I have some few remarks to offer thereon, as I have designed a large number of types of dynamos and experimented with a considerably greater number.

I think that the first thing we should settle, in dealing with this subject, is the type—what is the machine to do. If you are to run arc lights, your design must be entirely distinct and different from that which you use in running incandescent lights. The reason of that may not at first be so obvious; but if we consider the nature of an arc light, we will see it. An electric arc may be running so steadily—I speak now, of course, of the long quiet arc, what may be called the perfectly developed arc, not a hissing arc—that is a semi-incandescent light, and pertakes somewhat of the nature of an incandescent load for the machine; but a long well developed arc, with the crater fully exposed, burning quietly, possesses peculiar properties. If it is at a certain condition—10 amperes and 45 volts—and you increase the current slightly, you may convert that arc into a hissing arc abruptly with a great fall in its resistance. Now, what will be the effect if you have a machine which is worked a normal current of ten amperes on the straight part of its characteristic of that machine? You will find that the machine is not stable. The current will not stop at 10 amperes, if at this point of the current the field magnet coils, traversed by 10 amperes, do not saturate; the current in a series dynamo will continue rising, until a point is reached on the curve where the electro-motive force of the machine either drops or does not increase by the addition of current in its field magnet or exciting circuit. The consequence is that the successful arc lighting machine departs entirely from such terms as you find here. They go up to a certain point when the normal current is reached. There on the bend and a little beyond it the line dips, showing that an increased current drops the electro-motive force, and that is the condition of stability in running arc lights. The arc may be burning quietly. That will represent the wide open arc. [Illustrating.] You design your machine, we will say, with a large amount of iron in your armature and a large amount in your field; you save all the power you can; you make what may be called a very excellent type of an efficient machine and then you put on a circuit of arc lamps. You have calculated the excitation, etc. You expect to work the arc lights steadily. You find, on closing the circuit, that the carbons go apart; a tremendous roar of current comes through; the arcs draw wide open; suddenly the machine ceases to develop current—down they come and the operation is repeated continuously. The reason of that is that you have adjusted your arc lamps to run on 10 amperes, while your machine is not adjusted to furnish 10 amperes, and be stable under those conditions. The current is not stable until the field magnets have reached a certain degree of saturation—unless your arc lamp mechanism is extremely sensitive. Even in those conditions—I speak of course of the series machines—while the current in the field continues to increase, it causes a fall of resistance in the arc, a further increase of current, accompanied by a further increase of electro-motive force of these currents, and to such an extent that, as quickly as the arc lamp mechanism can act, it cannot get ahead of the increase of current. It is always behind time in drawing the arcs. It does not act instantaneously while its effects on the current are always headed off. Finally, there is a rupture of the whole circuit, down comes the carbon and we start again. That is a phenomenon we have met with frequently, and it comes always with an increased amount of iron beyond a certain proportion in the machine. We call it oscillating, surging or building up and dropping down—rough terms that we have used for the purpose of indicating the condition. It may be interesting to remark in this connection that we tried at one time compounding the machine and endeavoring to work it with a large amount of iron away below saturation, using a derived circuit winding to drop the curve at the proper point. Even in that case there was the same difficulty of surging or oscillation. Now, when we come to the design and construction of dynamos for incandescent lighting, or for motive power purposes, or for electric motor, then we have of course an entirely different set of conditions. Our resistance on the external circuit is not subject to this sudden drop of resistance, but demands more and more electromotive force to increase the current through it, and we have a dead resistance somewhat similar to a wire resistance. In that case you can work anywhere you please. On this line (indicating) you can work at about this point; and it may be that an explanation of some of the results Mr. Jackson has pointed out would be found in the fact that most dynamo builders prefer to work pretty low down on the curve. They do not like to buy their magnetism dearly. They would rather put in quantities of iron and diminish the copper in the field magnets, and get the magnetism at a rather low degree of saturation, and you will notice at this point that there is a very great difference. The differences begin to accumulate as you get up on that curve, so that if you are working at this point the difference is very large in relation to the amount of iron added; if you are working it here, the differences become less and less. But in motor work, we find by actual experience that we get very good results in constructing motors by putting in the armature core a rather larger amount of iron than has been customary. We have made the permeability of the armature very much lower than the ordinary practice of dynamo design has called for, and it is a question whether the movement in the direction of increasing the magnetic conductivity of the armature iron is not even with dynamos a proper move. The limitation to increasing the iron sections will be found between two conditions working against us, and the condition of increased output as shown by these curves working for us; that is, if we use the armature iron in larger sections. We may make it so that the changes of current increase the heat; that is the Foucault currents may trouble us; and if we make it of larger section also we increase the length of wire which is to go around it—longer turns of wire being required to cover the increased section—and those influences may be said to be working against us; so that there will be a point somewhere at which we will find the maximum conditions. In motor work our design of course is to pass as much as possible of the magnetism we develop through the armature, and the armature current itself assists us in doing that. There seems to be no reason why we should not use a comparatively large section of armature iron in a motor. We develop a field magnetism which we do not wish to have conducted out into the air and therefore we give it the best path possible through the armature. The motor would seem to be made of the best design when we have given a very ample section in the armature for the passage of the lines of force.

MR. MAILLOUX:—I would like to ask Mr. Jackson, whether his statement is that 75 °/₀ sectional area is what he considers the best proportion. In my practice, whenever I have used the Gramme ring, I have always used a sectional area, at least equal to the sectional area of the limb. I did that, not because I apprehended that I needed such a large amount, but because I realized that only a portion of that sectional area can be utilized—employed usefully in conveying lines of force. Some years ago, I discussed that question through the press and called attention to what struck me then as a new way of looking at the subject, and it is this—that as the lines of force make the ring their path in passing from one pole to another, it is quite evident that the tendency of lines of force like other things in nature, is to take the path of least resistance—the shortest path, and consequently to crowd each other. Now it is quite plain to my mind that there must be a condition of lines of force on the periphery of the ring on the outer surface, different from what there is inside, and consequently this must mean an increased resistance of penetration. In other words the coefficient of permeability must become lower, no matter what the magnetic resistance of the iron is at the point where the lines of force enter into the core, as well as where they emerge from it; so that we might have a core of very great section, and if the magnetic density, so to speak, is very great on the outer surface, then the resistance to further penetration will be so far increased that only a portion of the sectional area will be useful in conveying lines of force. I was led to look at this from the fact that a great many builders of Gramme rings have departed from the old method of constructing the core by fine wire, wound in a solid annulus, and instead have used laminated rings of more or less thickness and separated from each other at a certain distance. Now, I have noticed, that although they get much less weight of metal in a given area of section in an armature than would be the case if they used fine wire, yet they seem to obtain very nearly as good results; and it has always been a question in my mind whether the use of laminated rings, leaving a space between did not afford better opportunities for the lines of force to seek new paths—to enter by the side of each lamina, instead of being forced to enter at the periphery. I know that there is a great deal of diversity of opinion among physicists as to the possibility of a piece of iron being saturated at one part and not magnetized at another part. I remember at the electrical conference, the statement made by Prof. Silvanus Thompson, was harshly criticised when he said the central part of a core might not be magnetized, though the outside might be saturated. I do not know on which side of the fence to stand, but I am willing to be educated on that subject. I have been told by a maker of dynamos, that taking poles of very large sectional area, he could take out the central part of it without interfering at all with the nature of his characteristic curves. Those are significant points, and some information on them would be very acceptable.

The President:—We have two minutes before the lunch hour. If that time is not to be occupied by discussion, we will adjourn immediately, and I think, as we have so much business before us, it would be well to take simply an hour.

It was voted to take a recess for lunch, until 2 P. M.

AFTERNOON SESSION.

THE PRESIDENT:—The business of the afternoon is to take up first some very interesting phenomena, which will be brought to our notice by Professor Elihu Thomson, on alternating currents We all listen to the professor with the utmost interest and pleasure whenever he has an opportunity to address us. I am sure that on the present occasion it will be one of extreme pleasure and profit.

NOVEL PHENOMENA OF ALTERNATING CURRENTS.

BY PROFESSOR ELIHU THOMSON.

The actions produced and producible by the agency of alternating currents of considerable energy, are assuming greater importance in the electric arts. I mean, of course, by the term alternating currents, currents of electricity reversed at frequent intervals, so that a positive flow is succeeded by a negative flow, and that again by a positive flow, such reversals occuring many times in a second, so that the curve of current or of electromotive force will, if plotted, be a wave line, the amplitude of which is the arithmetical sum of the positive and negative maxima of current or electromotive force, as the case may be, while a horizontal middle line joins the zero points of current or electromotive force.

It is well known that such a current passing in a coil or conductor laid parallel with, or in inductive relation to a second coil or conductor, will induce in the second conductor, if on open circuit, alternating electromotive forces, and that if its terminals be closed or joined, alternating currents of the same rhythm, period or pitch, will circulate in the second conductor. This is the action occuring in any induction coil whose primary wire is transversed by alternating currents, and whose secondary wire is closed either upon itself directly or through a resistance. What I desire to draw attention to in the present paper, are the mechanical actions of attraction and the repulsion which will be exhibited between the two condctors, and the novel results which may be obtained by modifications in the relative dispositions of the two conductors.

In 1884, while preparing for the International Electrical Exhibition at Philadelphia, we had occasion to construct a large electro-magnet, the cores of which were about six inches in diameter and about twenty inches long. They were made of bundles of iron rod of about $\frac{5}{16}$ inch diameter. When complete, the magnet was energized by the current of a dynamo giving continuous currents, and it exhibited the usual powerful magnetic effects. It was found also that a disc of sheet copper, of about $\frac{1}{16}$ inch thickness and 10 inches in diameter, if dropped flat against a pole of the magnet, would settle down softly upon it, being retarded by the development of currents in the disc due to its movement in a strong magnetic field, and which currents were of opposite direction to those in the coils of the magnet. In fact, it was impossible to strike the magnet pole a sharp blow with the disc even when the attempt was made by holding one edge of the disc in the hand and bringing it down forcibly towards the magnet. In attempting to raise the disc quickly off the pole, a similar but opposite action of resistance to movement took place, showing the development of currents in the same direction to those in the coils of the magnet, and which currents, of course, would cause attraction as a result.

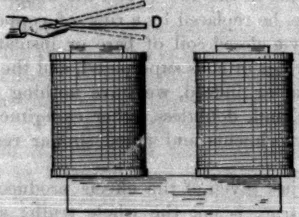

Figure 1.

The experiment was, however, varied, as in figure 1. The disc *D* was held over the magnet pole, as shown, and the current in the magnet coils cut off by shunting them. There was felt an attraction of the disc or a dip toward the pole. The current was then put on by opening the shunting switch and a repulsive action or lift of the disc was felt. The actions just described are what would be expected in such a case, for when attraction took place, currents had been induced in the disc *D* in the same direction as those in the magnet coils beneath it, and when repulsion took place, the induced current in the disc was of opposite character or direction to that in the coils.

Now let us imagine the current in the magnet coils to be not only cut off, but reversed back and forth. For the reasons just given, we will find that the disc D is attracted and repelled alternately; for, whenever the currents induced in it are of the same direction with those in the inducing, or magnet coil, attraction will ensue, and when they are opposite in direction, repulsion will be produced. Moreover, the repulsion will be produced when the current in the magnet coil is rising to a maximum in either direction, and attraction will be the result when the current of either direction is falling to zero, since in the former case opposite currents are induced in the disc D in accordance with well-known laws; and in the latter case currents of the same direction will exist in the disc D and the magnet coil. The disc might, of course, be replaced by a ring of copper or other good conductor, or by a closed coil of bare or insulated wire, or by a series of discs, rings or coils superposed, and the results would be the same. Thus far, indeed, we have nothing of a particularly novel character, and, doubtless, other experimenters have made very similar experiments and noted similar results to those described.

The account just given of the effects produced by alternating currents, while true, is not the whole truth; and just here we may supplement it by the following statements.

An alternating current circuit or coil repels and attracts a closed circuit or coil placed in direct or magnetic inductive relation therewith; but the repulsive effect is in excess of the attractive effect.

When the closed circuit or coil is so placed, and is of such low resistance metal that a comparatively large current can circulate as an induced current, so as to be subject to a large self-induction, the repulsive far exceeds the attractive effort.

For want of a better name I shall call this excess of repulsive effect the "electro-inductive repulsion" of the coils or circuit.

This preponderating repulsive effect may be utilized or may show its presence by producing movement or pressure in a given direction, by producing angular deflection as of a pivoted body, or by producing continuous rotation with a properly organized structure. Some of the simple devices realizing the conditions I will now describe.

In Fig. 2, *C* is a coil traversed by alternating currents, *B* is a copper case or tube surrounding it, but not exactly over its centre. The copper tube *B* is fairly massive and is the seat of heavy induced currents. There is a preponderance of repulsive action, tending to force the two conductors apart in an axial line. The part *B* may be replaced by concentric tubes slid one in the other, or by a pile of flat rings, or by a closed coil of coarse or fine wire insulated, or not. If the coil *C*, or primary coil, is provided with an iron core such as a bundle of fine iron wires, the effects are greatly increased in intensity, and the repulsion with a strong primary current may become quite vigorous, many pounds of thrust being producible by apparatus of quite moderate size.

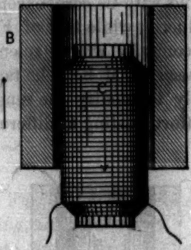

Figure 2.

The forms and relations of the two parts, *C* and *B*, may be greatly modified with the general result of a preponderance of repulsive action when the alternating currents circulate.

Fig. 3 shows the part *B* of an internally tapered or coned form, and *C* of an externally coned form, wound on an iron wire

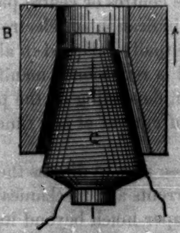

Figure 3.

bundle *I*. The action of Fig. 2 may be said to be analagous to that of a plain solenoid with its core, except that repulsion, and not attraction is produced; while that of Fig. 3 is more like the action of tapered or conically wound solenoids and taper cores. Of course it is unnecessary that both be tapered. The effect of such shaping is simply to modify the range of action, and the amount of repulsive effort existing at different parts of the range.

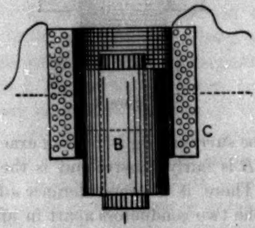

Figure 4.

In Fig. 4, the arrangement is modified so that the coil *C* is outside, and the closed band or circuit *B* inside and around the core *I*. Electro-inductive repulsion is produced as before.

It will be evident that the repulsive actions will not be mechanically manifested by axial movement or effort, when the electrical middles of the coils or circuits are coincident. In cylindrical coils in which the current is uniformly distributed through all parts of the conductor section—what I here term the electrical middle, or the centre of gravity of the ampère turns of the coils, will be the plane at right angles to its axis at its middle; that of *B* and *C* in Fig. 4 being indicated by a dotted line. To repeat, then, when the centres or centre planes of the conductors, Fig. 4, coincide, no indication of electro-inductive repulsion is given, because it is mutually balanced in all directions; but when the coils are displaced, a repulsion is manifested, which reaches a maximum at a position depending on the peculiarities of proportion and distribution of current at any time in the two circuits or conductors.

It is not my purpose now to discuss the ways of determining the distribution of currents and mechanical effects, as that would extend the present paper much beyond its intended limit. The forms and relative arrangement of the two conductors may be

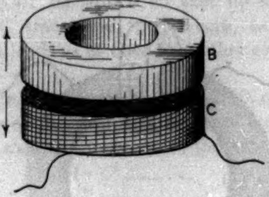

Figure 5.

greatly varied. In Fig. 5, the parts are of equal diameter, one, *B*, being a closed ring, and the other, *C*, being an annular coil placed parallel thereto, and an iron core or wire bundle placed in the common axis of the two coils increases the repulsive action. *B* may be simply a disc or plate of any form, without greatly affecting the nature of the action produced. It may also be composed of a pile of copper washers or a coil of wire, as before indicated.

An arrangement of parts somewhat analogous to that of a horseshoe electro-magnet and armature is shown in Fig. 6. The

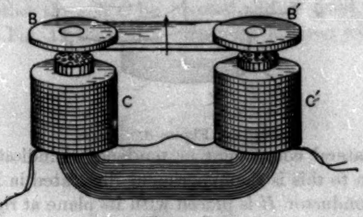

Figure 6.

alternating current coils *C C′* are wound upon an iron wire bundle bent into U-form, and opposite its poles is placed a pair of thick copper discs *B B′*, which are attracted and repelled, but with an excess of repulsion depending on their form, thickness, etc.

If the iron core takes the form of that shown by *I I*, Fig. 7, such as a cut ring with the coil *C* wound theron, the insertion of a heavy copper plate *B* into the slot or divided portion of the ring will be opposed by a repulsive effort when alternating currents pass in *C*. This was the first form of device in which I noticed the phenomenon of repulsive preponderance in question. The tendency is to thrust the plate *B* out of the slot in the ring,

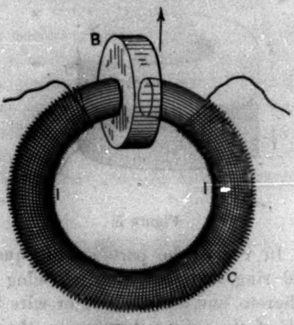

Figure 7.

excepting only when its centre is coincident with the magnetic axis joining the poles of the ring between which *B* is placed.

If the axes of the conductors, Fig. 5, are not coincident but displaced, as in Fig. 8, then, besides a simple repulsion apart, there is a lateral component or tendency as indicated by the arrows. Akin to this is the experiment illustrated in Fig. 9. Here the closed conductor *B* is placed with its plane at right angles to that of *C*, wound on a wire bundle. The part *B* tends to move

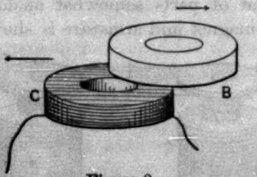

Figure 8.

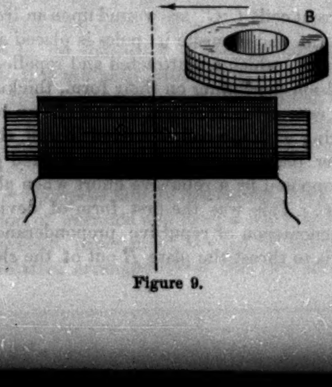

Figure 9.

toward the centre of the coil *C*, so that its axis will be in the middle plane of *C*, transverse to the core, as indicated by the dotted line. This leads us at once to another class of actions, *i. e.*, deflective action.

When one of the conductors, as *B*, Fig. 10, composed of a disc, or better, of a pile of thin copper discs, or of a closed coil of wire, is mounted on an axis *X* transverse to the axis of coil *C*, through which coil the alternating current passes, a deflection of *B* to the position indicated by dotted lines will take place, unless the plane of *B* is at the start exactly coincident with that of *C*. If slightly inclined at the start, deflection will be caused as stated. It matters not whether the coil *C* incloses the part *B* or be inclosed by it, or whether the coil *C* be pivoted and *B* fixed, or both be pivoted. In Fig. 11 the coil *C* surrounds an iron wire core and *B* is pivoted above it, as shown. It is deflected, as before, to the position indicated in dotted lines.

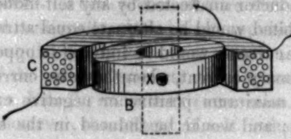

Figure 10.

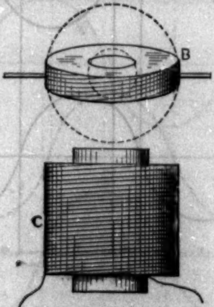

Figure 11.

It is important to remark here that, in cases where deflection is to be obtained, as in Figs. 10 and 11, *B* had best be made of a pile of thin washers or a closed coil of insulated wire instead of a solid ring. This avoids the lessening of effect which would come from the induction of currents in the ring *B* in other directions than parallel to its circumference.

We will now turn our attention to the explanation of the actions exhibited, and afterwards refer to their possible applications. It may be stated as certainly true that were the induced currents in the closed conductor unaffected by any self-induction, the only phenomena exhibited would be alternate equal attractions and repulsions; because currents would be induced in opposite directions to that of the primary current, when the latter current was changing from zero to maximum positive or negative current, so producing repulsion; and would be induced in the same direction when changing from maximum positive or negative value to zero, so producing attraction.

This condition can be illustrated by a diagram, Fig. 12. Here the lines of zero current are the horizontal straight lines. The

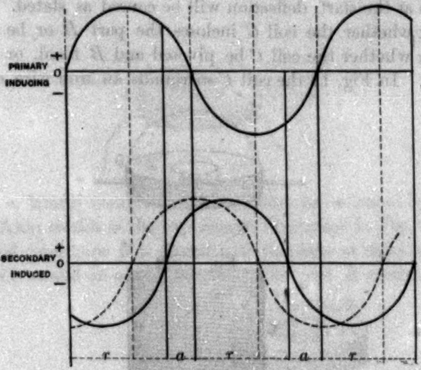

Figure 12.

wavy lines represent the variations of current strength in each conductor, the current in one direction being indicated by that portion of the curve above the zero line, and in the other direction by that portion below it. The vertical dotted lines simply mark off corresponding portions of phase or succession of times.

Here it will be seen that in the positive primary current descending from *m*, its maximum, to the zero line, the secondary current has risen from its zero to m^1, its maximum. Attraction will therefore ensue, for the currents are in the same direction in the two conductors. When the primary current increases from zero to its negative maximum *n*, the positive current in the secondary closed circuit will be decreasing from m^1, its positive maximum, to zero; but, as the currents are in opposite directions, repulsion will occur. These actions of attraction and repulsion will be reproduced continually, there being a repulsion, then an attraction, then a repulsion, and again an attraction, during one complete wave of the primary current. The letters *r*, *a*, at the foot of the diagram, Fig. 12, indicate this succession.

In reality, however, the effects of self induction in causing a lag, shift, or retardation of phase in the secondary current, will considerably modify the results and especially so when the secondary conductor is constructed so as to give to such self induction a large value. In other words, the maxima of the primary or inducing current will no longer be found coincident with the zero points of the secondary currents. The effect will be the same as if the line representing the wave of the secondary current in Fig. 12 had been shifted forward to a greater or less extent. This is indicated in diagram, Fig. 13. It gives doubtless, an exaggerated view of the action, though from the effects of repulsion

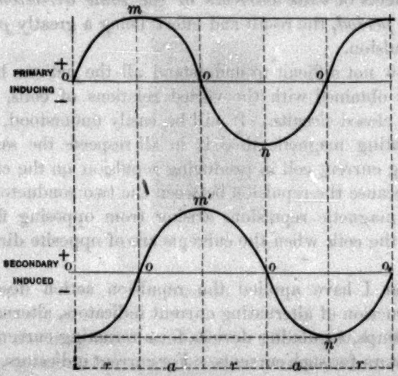

Figure 13.

which I have produced I should say it is by no means an unrealizable condition.

It will be noticed that the period during which the currents are opposite, and during which repulsion can take place, is lengthened at the expense of the period during which the currents are in the same direction for attractive action. These differing periods are marked *r*, *a*, etc., or the period during which *repulsion* exists is from the zero of the primary or inducing current to the succeeding zero of the secondary or induced current; and the period during which *attraction* exists is from the zero of the induced current to the zero of inducing current.

But far more important still, in giving prominence to the repulsive effect than this difference of effective period, is the fact that during the period of repulsion both the inducing and induced currents have their greatest values, while during the period of attraction the currents are of small amounts comparatively. This condition may be otherwise expressed by saying that the period during which repulsion occurs includes all the maxima of current, while the period of attraction includes no maxima. There is then a *repulsion due to the summative effects of strong opposite currents* for a *lengthened period* against an *attraction* due to the summative effects of *weak currents* of the *same direction* during a *shortened period*, the result and effect being a greatly *preponderating* repulsion.

It is now not difficult to understand all the actions before described as obtained with the varied relations of coils, magnetic fields and closed circuits. It will be easily understood, also, that an alternating magnetic field is in all respects the same as an alternating current coil in producing repulsion on the closed conductor, because the repulsion between the two conductors are the result of magnetic repulsions arising from opposing fields produced by the coils when the currents are of opposite directions in them.

Thus far I have applied the repulsion action described in the construction of alternating current indicators, alternating current arc lamps, regulating devices for alternating currents, and to rotary motors for such currents. For current indicators, a pivoted or suspended copper band or ring composed of thin washers piled together and insulated from one another and made to carry a pointer or index, has been placed in the axis of a coil conveying alternating currents whose amount or potential is to be indicated.

Gravity or a spring is used to bring the index to the zero of a divided scale, at which time the plane of the copper ring or band makes an angle of, say 15 degrees to 20 degrees with the plane of the coil. This angle is increased by deflection more or less great, according to the current traversing the coil. The instrument can be calibrated for set conditions of use. Time would not permit of a full description of these arrangements as made up to the present.

In arc lamps, the magnet for forming the arc can be composed of a closed conductor, a coil for the passage of current and an iron wire core. The repulsive action upon the closed conductor lifts and regulates the carbons in much the same manner that electromagnets do when continuous currents are used. The electro-inductive repulsive action has also been applied to regulating devices for alternating currents, with the details of which I cannot now deal.

For the construction of an alternating current motor which can be started from a state of rest the principle has also been applied, and it may here be remarked, that a number of designs of such motors is practicable.

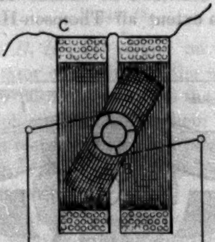

FIG. 14.

One of the simplest is as follows: The coils *C*, Fig. 14, are traversed by an alternating current and are placed over a coil *B*, mounted upon a horizontal axis, transverse to the axis of the coil *C*. The terminals of the coil *B*, which is wound with insulated wire, are carried to a commutator, the brushes being connected by a wire, as indicated. The commutator is so constructed as to keep the coil *B* on short circuit from the position of coincidence with the plane of *C*, to the position where the plane of *B* is at right angles to that of *C*; and to keep the coil *B* open circuited from the right angled position or thereabouts to the position of parallel or coincident planes. The deflective repulsion exhibited by *B* will, when its circuit is completed by the commutator and brushes, as described, act to place its plane at right angles to that of *C*, but being then open-circuited its momentum carries it to the position just past parallelism, at which moment it is again short circuited, and so on. It is capable of very rapid rotation, but its energy is small. I have, however, extended the principle to the construction of more complete apparatus. One form has its revolving portion or armature composed of a number of sheet iron discs, wound as usual with three coils crossing near the shaft. The commutator is arranged to short-circuit, each of these coils in succession, and twice in a revolution, and for a period of 90 degrees of rotation each. The field coils surround the armature and there is a laminated iron field structure completing the magnetic circuit. I may say here that surrounding the armature of a dynamo by the field coils, though very recently put forth as a new departure, was described in various Thomson-Houston patents, and to a certain extent all Thomson-Houston machines embody this feature.

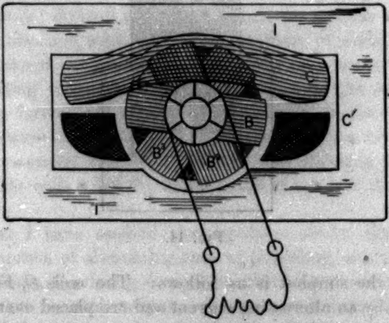

Figure 15.

Figures 15 and 16 will give an idea of the construction of the motor referred to. *CC*¹ are the field coils or inducing coils which alone are put into the alternating current circuit. *II* is a mass of laminated iron, in the interior of which the armature revolves, with its three coils B, B^2, B^3 wound on a core of sheet-iron discs. The commutator short-circuits the armature coils in succession in the proper positions to utilize the repulsive effect set up by the currents which are induced in them by the alternations in the field coils. The motor has no dead point and will start from a state of rest and give out considerable power, but with what economy is not yet known.

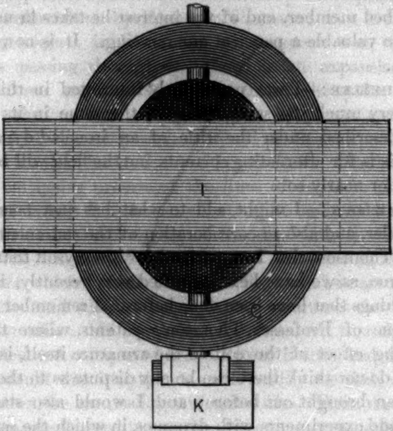

Figure 16.

A curious property of the machine is that at a certain speed, depending on the rapidity of the alternations in the coil *C*, a continuous current passes from one commutator brush to the other, and it will energize electro-magnet and perform other actions of direct currents. Here we have, then, a means of inducing direct currents from alternating currents. To control the speed and keep it at that required for the purpose, we have only to properly gear the motor to another of the ordinary type for alternating currents, namely, an alternating current dynamo used as a motor. The charging of storage batteries would not be difficult with such a machine, even from an alternating current line, though the losses might be considerable.

DISCUSSION.

THE PRESIDENT:—I think we have reason to be proud of our distinguished member, and of the interest he takes in us when he presents so valuable a paper at our meeting. It is now open for discussion.

MR. WHEELER:—I was particularly interested in this, because I heard very much the same thing, or the same in its principle features described under the title of an ironclad dynamo. Of course, this is for alternating currents, but the field will be an iron-clad field, or nearly so.

MR. MAILLOUX:—I might add to what has just been said by Mr. Wheeler, and also in corroboration of the statement made by Professor Thomson, that I am perfectly aware myself that the iron-clad dynamo, as we have heard it called very recently, is another of those things that have been done before. I remember distinctly reading one of Professor Thomson's patents, where the direct magnetizing effect of the coil on the armature itself, is adverted to; and I do not think there can be any dispute as to the fact that it had been brought out before; and I would also state that I myself made experiments with dynamos, in which the same result was accomplished as early as 1879.

There is one interesting point that is mentioned by Professor Thomson. I think it is the phenomenon which he illustrated by means of his first figure, noting the repulsion and the attraction that take place when the current is reversed in an ordinary magnet. I could not help thinking, at the time, of some experiments made some years ago by Professors Elphinstone and Vincent, and about which I once took it into my head to write something. The fact was brought out by Messrs. Elphinstone and Vincent of the importance of the magnetic circuit that we now so well know and use in dynamo-electric machines. I had been very much struck by the statement of Faraday in his "Experimental Researches," where he speaks of lines of force expanding during the action of the beginning of current through a circuit, and of their collapse when the current is discontinued or decreased, and I remember making a note in this article (which you will find somewhere in the London *Electrician*, several years back) of experiments or observations made by me to show that that phenomenon was observable in an ordinary electro-magnet. I have been able by means of a delicately suspended needle or by a very thin piece of iron wire fast to the pole, so that it might place itself in the lines of force and follow the oscillations of the lines of force, to trace a positive motion in the lines of force which would be exactly corresponding with that just referred to by Professor Thomson; in a word, when the electro-magnet is in process of magnetization, when the current is passing through it,—there is an expansion of the lines of force starting apparently from the yoke, and the effect of the motion of these lines of force re-acting on the disc would be exactly such as would produce repulsion in accordance with the phenomenon of Lenz's Law. On the contrary there is a collapsing process of the lines of force in the process of demagnetization and the action would be again such as to produce attraction or the dragging of the disc with it. Now, with regard to the difference of repulsive and attractive effect, there is another fact which I think Professor Thomson has not taken into consideration and which to some extent increases the difference of repulsive effect. If we assume for a moment that the process of expansion and collapse of lines of force is true, and I have no reason to doubt that it is, then we will readily see that, as our current is put on, we are dealing with quantities. First, the resistance of the diamagnetic medium to the stress that is produced by the current, and second, the amount of energy or the rate at which we supply energy to overcome that elasticity. I might also add, of course, a third quantity, which is reaction produced by self-induction of surrounding metal; but when the collapse takes place we have the action of the pent-up energy that has been stored by the process of contraction. I might explain this by taking a piece of rubber and stretching it. The rapidity with which it is stretched depends upon the rate at which energy is applied to it and on the elasticity; but when I let go, it falls back by virtue of its own elasticity, nothing else. In the case of the secondary coil we can deal with this self-induction, but there are experiments which have been made, I think, by Professor Von Beets, which show very clearly that the impulse of collapse is much more rapid than the impulse of rise. Consequently there would be a difference of current in the inductive circuits, which would tend if we follow them carefully by means of the curves produced by Professor Thomson, to emphasize that difference of action in favor of the repulsive process. I would like to hear the views of other gentlemen, who are well informed on these subjects.

MR. PRESCOTT:—Professor Thomson has so clearly and beautifully described the experiments he has made that he has left hardly anything to be asked. I would say that I am particularly interested in the application to measuring instruments, and I would like to know whether in the application he has discovered, the repulsion is inversely proportional to the square of the distance of the plates, and if so whether he has preferred to make his instruments to measure that distance directly, or whether he has preferred to counterweight or in some way counteract the movement so as to keep it always constant.

He has paid so much attention to this question of alternating currents that I should like to ask him also whether he has made any experiments to determine, for instance, whether a secondary battery, in the circuit of an alternating current machine, would cut off a portion of the electromotive force in one direction which was counter and equal to that of the battery itself, in which case an ordinary current instrument would measure the distance if connected around the poles of the battery.

Professor Thomson:—In regard to the measuring instruments, I have used the principle in several ways. The matter has not been carried sufficiently far as yet to determine all the points on the subject, but I have used gravity and a spring as a counterforce device. However, I find there does not seem to be any regular law, perhaps any more than there is with an electro-magnet, for the decrease of the effect by distance, except when the distances become very large. The very fact of a change of position changes the relations of the currents themselves and of the relations between the two currents, so that we can hardly regard the problem as any different from the problem of an electro-magnet attracting its armature. When the armature is placed at a certain distance, there is a certain distribution of magnetism; when it is taken to another distance the distribution is so changed that we could not consider that the centre of gravity, so to speak, of the magnetism, is the same in the two cases, and the redistribution will depend on the length, the diameter of the core and the sizes of the armatures, so that the problem becomes a very complex one. But I have made a very curious application of the principle in this way: I have taken an ordinary fruit jar and put in it a disc of a certain thickness and attached to it a bulb of glass and immersed it in alcohol or water and adjusted it, until the gravitational effect was so overcome by the flotation, that it was almost indifferent as to position, but it would just settle down to the bottom of the jar. I then put an alternating current coil below it and passed a current of gradually increasing amount. Gradually the disc would begin to lift itself, and at a certain current would float to a certain height, standing in the liquid supported by the repulsion. There we have a very excellent illustration and a means of getting at

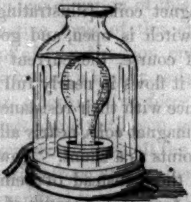

Figure 17.

probably the relative repulsive effort under different conditions.

In regard to the point brough up by Mr. Mailloux, concerning the more rapid drop in the current at the end of a wave, I think that he must have been considering the effect of interrupted currents only, as in the ordinary induction coil—that is, you pass a primary current through the primary coil, as a battery current, and on closing the circuit the counter-electromotive force developed keeps down the current, and it slightly rises to that current which can pass with the electro-motive force present acting over the resistance of the primary circuit. But when you cut off the current, the secondary current is much more vigorous in electromotive force than that on making the circuit of the primary, but does not last as long. In the primary, surrounded by its secondary, when we put on the current or close the circuit, there is an opposing electromotive force; the battery does not get its full amount of current for some time, and during that time the secondary currents will seek to evolve their energy; that is, they have duration without great force. But when we cut the battery current off and do it specially with a condenser which enables us to open the contact without sparking, or in other words, to cheat the current a little and give it another path for the time being, the secondary then gives out considerable electromotive force or energy.

I may mention an interesting experiment in this connection showing the effects of self-induction in magnets—a very curious experiment tried with a large magnet. It has nothing to do with the repulsive effect; it has to do with self-induction and the curious effects produced by it in lagging or stopping waves and preventing waves from having their full value. We put this magnet into circuit with a dynamo and we make a shunt of carbon points—a shunting switch made with carbon contacts, as they might be placed in an arc light. The current comes through this way through the magnet coils [illustrating on the black-board], when the shunting switch is open, and goes on. We close the carbon switch, and, of course, the current gradually leaves the magnet and gradually it flows in nearly full volume over the carbon points in accordance with their resistance. If their resistance is much less than the magnet coils, nearly all the current will flow through the carbon points as a shunt. Now, on opening the carbons, the arc formed there instead of being a good, strong, full arc, will simply be the tops of the waves of the current, while a steady current will flow through the magnet. That is, you will have a steady current in the magnet, and the tops of the waves will be chopped off and sent through the carbon. There is no self-induction in this carbon branch, and the current there in the magnet branch is steady. In fact, the spark you get here at the carbons or the arc you get here will very closely resemble the spark obtained from the Rhumkorff coil—a thin spark with a considerable aureola, and not very hot. I have drawn them three-quarters of an inch long; playing and sputtering, showing that the waves of the current are having their true effect in provoking undulations of sound, whereas an ammeter put in the magnet circuit or branch shows a current pretty nearly the line current.

There was one other point on which information was asked for. It has just slipped my mind.

MR. PRESCOTT:—In regard to the secondary battery and the alternating current circuit.

PROFESSOR THOMSON:—That is a question that I have not investigated at all, but there would be a current of double volume in one direction and a stoppage in the other direction provided the volts of counter-electromotive force were right. There is a possibility of producing a current of this character by combination of an alternating current machine and a dynamo and a continuous current machine. We may have a current like that (illustrating) produced, which would approximate the current that you were asking about. Whether applications of such currents will ever be made or not I do not know.

Mr. Prescott:—The point I wanted to make is a little different. Suppose that an alternating current is passing through that wire (illustrating) and that at this point here we introduce a counter electromotive force, or a certain electromotive force in one direction, and we have a resistance in circuit with it, connected in *here*. Now, suppose this point to be shifted until the difference of potential in one direction of this alternating current is equal to the electromotive force of this opposing battery; then there will be a current of one direction only through this wire, and if that is the case having a known resistance in here you have simply to interpose an electromotive force in one direction and shift its point of contact along until you get no deflection in the galvanometer, then you would have all the data necessary to determine the electromotive force of the alternating current. Something like this was suggested to me by Mr. John Howell, of the Edison company, and he wanted me to try it. It was very recently and I have not yet had an opportunity of doing so.

The President:—We have with us Mr. Pendleton, President of the New York Electrical Society, who is very much interested in this subject and we should be most happy to hear from him anything he may wish to say.

Mr. Pendleton:—I came here this afternoon more particularly to take a back seat and listen; I am grateful for the hospitality with which you have received me, and thank you for the invitation to speak upon the subject now under discussion. It is, however, not one to which I have given much thought, and it has been so thoroughly demonstrated that I feel that there is but little for me to say. In regard to the secondary battery application that the gentleman has just made, I should fancy the result would be the steady discharge of the battery of whatever charge it might have; and I believe it would be impossible to accumulate chemical energy in the battery under such circumstances. While I was listening to Professor Thomson's interesting account of his experiments, it occured to me that if the actions are sufficiently delicate, there is a great variety of applications for it, several of which he mentioned, and also that it would be possible, in connection with the telephone, to make a recording instrument, which might at any rate equal the success of the Edison phonograph. In this case it would be a reproduction of the waves of sound in the same manner. I merely make the suggestion in addition to those Professor Thomson made.

Mr. Mailloux:—I merely wish to ask Professor Thomson to tell us the results, if he has any, in regard to the measurement of electromotive forces of alternating currents, as the subject seems to be receiving some attention in the discussion.

Mr. Thomson:—I would be glad to give way to gentlemen who have tried to get an opportunity to say something.

Mr. Hering:—I would like to ask Professor Thomson how the magnetic attraction compares with its induction. If the closed copper disc were to be made of iron, there would be attraction; now, how does that attraction compare with the repulsion in case it is not magnetic. I ask that, in order that we may get some idea of the strength of this repelling force.

Prof. Thomson:—I have not made any determinations with that object in view—that is, to determine the relation between, as I understand it, electro inductive repulsion and the attraction of the magnet coil for its core. I think we can say, however, that it compares very well, only that the copper band, of course, naturally occupies a greater space and uses energy of current flowing in it. If we have a current flowing in a coil attracting an iron core, and the iron core is thoroughly divided so as to avoid currents in the iron itself, we would get electro-magnetic attraction pure and simple without necessary loss of energy; but in the case of the copper band there is undoubtedly, where large work is being done, a loss of energy, due to the flow of heavy currents in the conductor; but in the case of a disc which is deflected, the disc saves itself that loss by throwing itself more or less at right angles. It is only when you are resisting motion by a counter-weight that the loss amounts to much. Allow the thing to move and it relieves itself of the stress by leaving the point of greatest stress.

Mr. Powers:—I had a very interesting experience in the line of Professor Thomson's address, about the lag of heavy currents, which I wish to bring to your notice, and be somewhat personal about the matter again. At Troy, we are making an alternating current dynamo, producing direct currents from it; in other words, a simple multi-polar dynamo, with this exception, that the armatures are in two layers, the neutral point on one armature corresponding with the maximum point on the other. Those two armatures are connected to a single commutator, there being two bars connected with one armature and the next two bars with the other; the positive of one and the positive of the other, the negative of one and the negative of the other; in that relation, a brush being put on there of a certain width, we found some curious results. With plating machines of low tension we found we could increase the width of contact to such an extent that we seemed to collect the entire current from both sides of the armature; in other words, the current seemed to be prolonged from each side of the armature so that we were practically collecting the current from both sides. The moment we got the high tension currents we failed. Without apparent lag of the current, whatever that was, the minute we increased the tension of currents up to three or four hundred volts, we failed entirely. But the point I wished to bring to your attention was that we could make that contact of considerable width and apparently get a larger power from the same amount of material in the machine, in low tension work, than we could when we got too high tension, and apparently there existed this feature of lag of heavy currents which Professor Thomson first brought up.

Professor Thomson:—I do not think you can say that heavy currents lag any more than light currents. A heavy current is nothing more or less than the flowing around of so many lighter currents. In a closed circuit coil it is the same current going round many times, as compared we may say with many parallel currents in a band, which represent the currents that pass in a fine coil repeated side by side so many times, and the lag ought to be the same in both cases. I find, for example, that it does not matter in these experiments whether I use a copper ring or a closed coil or a finely wound coil; I might use number 36 wire, provided that I could get as much copper into the same space with the number 36 wire as I could get with a heavy mass of copper. That, of course, I cannot do; but if I could, I haven't the slightest doubt that the electromotive force currents, closed on themselves, would have the same lag as heavy currents closed on themselves. In one case there is greater length; in the other there is greater volume, both of which cause lag of the current.

Mr. Powers is probably working with high potentials in one case and quite low potentials in the other. Now, a high potential machine is a ticklish thing to handle anyhow. You must put your brushes on and carry the coil terminals away from them not a moment too late or you will have a flash and short circuit of the commutator from one point to the other. I am speaking of the type of machine to which you refer. The low potential current, how ever, permits us to have a considerable variation in the point of commutation, without provoking bad sparking and flashing; you no doubt are able to use an extra over-lap of brushes on the low potential machine bringing coils into action at the moment they begin to be active, or are developing very low electromotive force and taking them out of action when they are developing nearly no electromotive force. That you could not do in a machine of such type with high potentials, because if you keep the coils in beyond their time of possessing electromotive force which could just sustain the circuit, you would have a flash; there would be an alternation at the slot in the commutator which would cause a reverse current.

Mr. Powers:—The action I was speaking of was not flashing at the commutator, but the curious growling of the machine against itself; for instance the relation between ten volts and one hundred volts on the same machine if you choose to couple them up directly, and the same brushes, would give you that slowing down and growling effect, while in the other case the brushes worked smoothly and gave good results.

Professor Thomson:—I misunderstood the point in question.

Mr. Pendleton:—The subject has brought up a matter which was of considerable interest to me sometime ago. The different action upon the magnetization of a differential magnet in a lamp that I invented some three or four years ago, may be somewhat analogous to the action that is found in the difference between these two makes. It was an unexplained action so far as I could get at it; but some one may be able to give the reason for the fact. An ordinary differential lamp, extended poles acting upon an armature which governed the carbon rod, I ran for several weeks upon the circuit of the United States Electric Light Company to good advantage. The lamp worked well and the feeding point and polarization of the cores was correct and worked very satisfactorily. I had occasion afterwards to put the same lamp upon a high tension current and found that consequent poles were developed in the iron and the lamp although it worked, yet at the same time was working under great disadvantage. Mr. Field at the time examined the lamp; and while he spoke well of its mechanism remarked one day, "Pendleton you have got a bug in that lamp." "Well," said I, "I have, but how did you find it out?" "I had the same difficulty some years ago in meeting with consequent poles." I then told my experience with the lamp,—

that with low tension—it ran perfectly well, and then consequent poles were not formed. I remedied it, however, by placing upon each core the two differential magnets—as it were on one spool, the coarse wire and fine wire. Now, in this action spoken of, between the high and low tension currents, I find there may be some similarity of action; and it is a matter that has not been thoroughly ventilated. I have never been able to account for it. I remedied it, but the cause of it I have never been able to ascertain. There are a great many things in the matter of magnetization, simple though it may be, that we are foggy about.

THE PRESIDENT:—We have other items on the programme, and interesting as this subject is, and attractive as it is, I think we shall have to move on. Mr. Shelbourne will you kindly take the chair.

MR. SHELBOURNE took the chair, and MR. MARTIN read the following paper, entitled, "A Few Comparative Statistics of Electrical Railways."

A FEW COMPARATIVE STATISTICS OF ELECTRIC RAILWAYS.

BY T. COMMERFORD MARTIN.

It is not now my intention to present a paper on the general subject of electric railways. That I did at a meeting of the Institute, held last December, when I was enabled to offer a few statistics on the electric railway as compared with horse, cable and other methods of traction for street cars. I have found since then a great desire generally for information as to the status of electric roads in the United States and Europe. Street railway men, investors and others have wished to know whether such a thing as an electric road was really operating anywhere or not, and, if the lines were running, what the cost of construction and operation was. The tables I submit herewith are intended as an answer to those queries. It has been difficult to get at a common basis of estimate and statement. With regard to the European roads, I would say, that I have been greatly indebted for the figures to a most admirable and exhaustive paper, read a few weeks ago by Mr. Anthony Reckenzaun, before the London Society of Arts. In Europe, as here, various systems of transmitting the current and of connecting up the motor with the car axles and wheels are in use, and as yet, no determination as to the best method seems to have been reached.

Respecting the figures for this country, I would say that they are necessarily very much in the shape of an estimate as to the number of passengers; though, by allowing each car only 50,000 passenger a year—merely 150 a day—my calculations come out as rather low. The facts may be summed up by saying that, in Europe, the electric railways are now carrying passengers at the rate of 3,000,000 annually. In America, they are carrying at the rate of over 3,500,000, and when the roads now building are finished—to say nothing of the scores for which contracts are being made—the number carried will be at least 7,000,000 annually. When the roads at the places I enumerate in the tabular footnotes all go into operation, the number will be easily quadrupled. As to cost, I would remark that in every instance yet brought to notice, electricity has spelled economy. I saw recently some authentic and extremely elaborate statistics for 1879 of street railways and their cost in New York and Brooklyn. They were taken from the various official reports. The showing for the total cost of operation per car ranged between $8 and $10 per day at that time. The saving on that with electricity is, according to circumstances, at least 25 to 40 per cent. with heavy traffic. I have provided copies of the following tables for distribution among the audience and need not read them.

ELECTRIC RAILWAYS IN EUROPE, APRIL, 1887.

PLACE.	Length.	Motors and Motor cars	No. of Passengers.	Freight.	Total Expense of operation.	Car miles run yearly.	System of Conductors.	Prime Power.
Lichterfelde-Berlin, 1881	1½ miles.	2	100,000 yearly.	....	....	....	All rail.	Steam engine.
Brighton, 1883	1 mile (single track).	2	1,000,000 total.	....	1.92 pence per car mile.	46,950.	All rail.	Gas engine.
Moedling-Hinterbruehl, 1884	2.8 miles (single track and sidings).	12	340,000 yearly.	....	3.42 pence per car mile.	91,002.	Overhead slotted tubes.	Steam engine.
Frankfort-Offenbach, 1884	4.1 miles (double track).	14	990,000 yearly.	....	3.83 pence per car mile.	292,269.	Overhead slotted tubes.	Steam engine.
Zankerode (mine) 1882	790 yards (double track).	1 locom. 16 wagons.	....	300 tons daily.	.77 penny per ton.	660 wagons daily.	Overhead inverted ⊥ rail.	Steam engine.
Hohenzollern (mine), 1884	820 yards (double track).	1 locom. 15 wagons.	....	300 tons daily.	.5 penny per ton.	600 wagons daily.	" " "	Steam engine.
Portrush, 1883	6 miles (single track).	4	Over 100,000 up to 1885.	....	2½ pence per car mile.	....	Third rail.	Water power.
Besspool, 1885	3 miles (single track).	8	300,000 yearly.	30,000 tons yearly.	4 pence per train per mile.	60,000 train miles yearly.	Third rail.	Water power.
Blackpool, 1884	2 miles (single and double).	10	Over 1,000,000 total.	....	Less than 4 pence per car m.	....	Conduit.	Steam engine.
Brussels, 1887	....	5	....	....	....	....	Operated by storage batteries.	....
Hamburg, 1886	....	2	....	....	....	....	Operated by storage batteries.	....

NEW ROADS.—A special charter has been granted by the Austrian Government for a road in the Austrian Alps, to cost about $350,000, and to be 15 miles in length.

A road is being built in the great salt mines at Stassfurt, Germany.

The North Metropolitan Tramway Company in London has several motors now ready for use with storage batteries, on its line, awaiting powers from Parliament.

ELECTRIC RAILWAYS

PLACE.	Length.	Motors and Motor Cars.	No. of passengers.	Freight.
*Baltimore, Md. 1885	2 miles (single track with turn outs.)	6	260,000 yearly.	
*Los. Angeles, Cal. 1887.	3 miles, single and double	8	200,000 yearly.	
*Port Huron, Mich., 1885-6	4 miles, single track.	8	275,000 yearly.	
*Windsor, Can., 1885	Nearly 2 miles, single track.	2	200,000 yearly.	
*Highland Park, Detroit, Mich., 1886	3½ miles, single track.	2	200,000 yearly.	
*Dix Road, Detroit, Mich., 1886	1¾ miles, single track.	4	300,000 yearly.	
*Appleton, Wis., 1886	4½ miles, single track & double	8	400,000 yearly.	
*Scranton, Pa., 1886	3¼ miles, single track four sidings.	3	300,000 yearly.	
Denver, Col., 1886	3½ miles, single and double.	7	500,000 yearly.	
Montgomery, Ala., 1885-86	11 miles, single and double.	18	This ran 2 cars one year. Have just started other cars. (1,000,000 yearly.)	
†Kansas City, Mo.				
Orange, N. J., 1887.	½ mile built.	1		
Boston, Mass. (sugar finery), 1887	Short track within the works.	1 locomotive, 3 cars.		The cars in constant use all day; the loads averaging 10 tons per trip, and each round trip averaging 5 minutes.

*Extending line or increasing rolling stock.

New Roads—Electric railways are now in course of construction, or under contract, at Pittsburgh (3 roads): Los Angeles; Binghamton, N. Y., 4½ miles, 8 motor cars; Lima, O., 3 miles, 6 cars; San Diego, Cal., 9 miles, four 40 h. p. motor cars; Ansonia, Conn., 3½ miles (water power); New York city (for Fulton Street); St. Joseph, Mo., 20 cars; Mansfield, O.; Ithaca, N. Y.; Harrisburg, Pa.; Woonsocket, R. I.; Richmond, Va., 40 cars, 11 miles of track.

IN AMERICA, MAY, 1887.

Expense of operation.	Car miles run.	System of Conductors.	Prime power.
$4 per car per day.	Each motor runs 73 miles daily.	Third rail and overhead wire.	Steam engine.
....	....	Single and double overhead wire.	Steam engine.
....	....	Single overhead conductor.	Steam engine.
$4 per day for power.	64 miles each car per day.	Single overhead conductor.	Steam power from electric light station.
80 cents per day for fuel.	Each runs 13 hours daily; capacity 30 passengers; speed 15 miles an hour.	Sunken central rail.	Steam engine.
....	The trains run from 6 a.m. to 11 p.m.	Double overhead conductors.	Steam engine.
For power, wages of one man as they own their own water power.	17 hours daily.	Double overhead wire.	Turbine water wheels.
$9 per day for power, but are putting in their own engine.	Each car runs 85 miles per day.	Overhead wire.	Steam power from electric light station.
$1.50 per day for fuel.	....	Conduit for series system.	Steam engine.
Fifty per cent. less than horse and mule traction—General Managers report.		Overhead conductor.	Steam engine.
....	....	....	....
....	....	Overhead conductor.	Steam engine.
	....	Overhead conductor.	Operated from the lighting dynamo.

†No specific details received, line not being yet in regular operation.

Companies have been formed or steps taken to build and operate electric roads at Flushing, L. I. (2); Lincoln, Neb.; Brookline, Mass. (2); East Cambridge, Mass.; Newton, Mass., Boston, Mass.; Asbury Park, N. J.; Pelham Park, N. Y.; New Brunswick, N. J.; Plainfield, N. J.; Bayonne, N. J.; Worcester, Mass.; Scranton, Pa.; Carbondale, Pa.; Philadelphia, Pa.; Reading, Pa; Bangor, Me.; Biddeford, Me.; Westfield, Mass.; Chicopee, Mass.; Muncie, Ind.; Gratiot, Mich.: Tiffin, O.; Cincinnati, O.; Brooklyn, N. Y.; Coney Island, N. Y.; Rockaway, N. Y.; Winston, N. C.; Jacksonville, Fla.; Pensacola, Fla.; Birmingham, Ala.; Selma, Ala.; Atlanta, Ga.; Fort Smith, Ark.; Wichita, Kan.; San Francisco; San Jose, Cal.; Newton, Kan.

The Chairman:—Gentlemen, this question of electric railways is one which is very full of meat and very full of promise; it is something which it seems to me will immediately develop itself extensively, and that within the next two years we will have five times the number of electric railways in operation that are now in operation, and electric railways of more extensive routes. This morning, Mr. Frank L. Pope, our worthy past President, made some statements in regard to investigations which he had pursued with reference to that subject, and I, at that time, felt on the point of asking, as he did not state, the location of the proposed railway, nor kind of battery he had calculated upon. Whether in his calculations he took as the basis the storage battery that he had investigated, that is, the Julien battery, as I understood it, and whether he made any estimate as to the comparative percentage of cost for running a car per mile per hour with such a battery as compared with horse power.

Mr. Frank L. Pope:—In reply to the Chairman I would say that I did not mention the kind of battery used, nor the name of the railway for which we were making tests, simply to avoid the appearance of utilizing this meeting for advertising purposes; but I have no objection to making the statement. The concern referred to is the West End Street Railway Company of Boston and the battery of which we have completed a test is the Julien. I may say that we have devoted a good deal of attention to getting at, as nearly as we can, in the absence of actual experiment on the road under working conditions. The probable comparative cost of power, I think, will come to about seven cents per car mile as against ten to eleven cents per car mile by horse; experience may modify these figures; but I do not think they will be far from the true cost. We have taken great pains to get accurate data.

Mr. Martin:—This paper is presented as a substitute for the one for which I appear upon the programme. That was to have been prepared chiefly by my associate, Mr. Wetzler, who has been sick and consequently not able to give it attention.

The Chairman:—It seems to be necessary, gentlemen, in order to get through in time this afternoon, that we hurry on to the next paper, which is a paper by Mr. J. A. Powers, of Troy, on the installation of arc lighting plants.

Mr. Powers:—Mr. President and gentlemen, there seems to have been a pleasing variety of misunderstanding about my subject. Arc lighting plants are included in my paper; but I had proposed to treat of the installation of central stations or rather of central station construction.

Mr. Powers then read the following paper.

CENTRAL STATION CONSTRUCTION.

BY J. A. POWERS.

There are two ways of constructing a central station for electric lighting, each of which has its special object. They may be defined as the speculative and the investment plans. The first has as its legitimate, or rather illegitimate end, the sale of the plant to some unfortunate, perhaps unwilling capitalist, by fair means or foul. We may consider as fair means the not uncommon method of selling a small portion of the stock, perhaps just enough to pay for the apparatus, on the strength of a showy exhibition in the hands of an expert, who uses all the tricks of the trade to persuade his lambs that his system will produce double the light with half the power of any other, and the other customary arguments.

The foul means is the border-ruffian money-or-your-life policy, which enters a territory already sufficiently well served, not for fair competition, but to make money by being bought out.

The electric light business is rapidly emerging from the border-ruffian and blackmailing stage; and, as we may shortly expect these methods to be relegated to their proper realm with other things dead and dishonorable, with the growth of popular knowledge of electrical matters, we will leave them, and proceed to the more legitimate methods which I hope you will all pursue.

"The fool doth think he is wise, but the wise man knows himself to be a fool," said the master of all writers; and that I may be saved entering the first class in your presence, I here confess to many and grievous mistakes in our own central station construction, to which this paper owes its being, for, that I may hope to save some of you part of my errors is my only excuse for appearing befor you.

Let us, then, drop speculation as a thing of the past in our business, and make our object the construction of such work as shall produce, in the sober judgment of every business man among you, the best results in economy of labor, supplies and power, with the least expenditure for interest, taxes, insurance and repairs.

In all manufacturing enterprises of the day, one tendency is unmistakably felt. It is the direction of thorough work. To succeed in any established business, one must have substantial buildings, the *best* improved machinery, the best site for obtaining necessary supplies at their cheapest. Electric lighting to-day has risen from the slough of speculation and stands side by side with other great manufacturing enterprises in importance. Not less than sixty millions of dollars are invested in lighting plants alone, and in the entire field probably not less than double that sum. Has not the time come when the same laws of strict economy which obtain in other large enterprises should govern central station construction?

Let us carefully consider our problem, plan cautiously, and expend liberally in the directions which indicate the best results. It is evident, however, that we should not expend without limit. Where shall we draw the line? I believe we are safe in expending every dollar which is sure of saving 10 per cent. interest on its investment, provided we have it to spend. The only danger in the path seems to be the chance of such improvements as shall throw aside our present methods of producing electricity. Let us for a moment consider the possibilities in this direction. The best dynamos will to-day, in ordinary practice, convert eighty to eighty-five per cent. of the power furnished them into an equivalent of electricity. Clearly there can be but small improvement here. Coal or similar fuel is the common source of power to-day, and seems likely to remain so. The best steam plants give one horse-power hour for about one and one-half pounds of coal. The actual energy stored in that one and one-half pounds of coal would give about seven horse-power hours if it could be converted into power without loss, or, in other words, the best steam plants of to-day have an efficiency of about 13 per cent.

Prof. Houston remarked, at the last convention of the National Electric Light Association, that the field where lies the greatest chance for improvement is in the direction of thermo-electricity, the conversion of heat into electricity without the intervention of power. This is most certainly so; for if a process can be discovered which will have a reasonable efficiency, say 25 per cent., electric motors must soon supersede steam engines for power. The nature of the losses connected with the conversion of heat into other forms of energy does not, however, give much encouragement in this direction. The nature of such losses is in the diffusion of heat by conduction and radiation, which has always proved most difficult of control. If a process of simple conversion, without the attendant development of heat, can be devised, the chances of a good efficiency would be much improved, but where heat exists, there is radiation, and where radiation is, there will be serious loss. How serious, we can only judge from our experience with the steam and other heat engines. It is probable that we are safe in investments in our expensive steam plants, at least to the extent of the life of these plants. Let us then return to our subject proper. The first matter of importance to be decided in establishing an electric light station is its location. The necessary qualifications for location may be classed about as follows:

1st. A dry soil—a gravelly soil, which will easily leach away the runnings from small drips or leaks, is preferable, next to solid rock. If located near a river, a wide margin of safety from flood should be allowed.

2d. If practicable, a location near a plentiful water supply should be chosen. Condensation of either high or low pressure engines is desirable in every way, and requires a large water supply.

3d. Nearness to the coal supply. If possible, locate, near a navigable stream, so as to secure cheapness of handling coal and a plentiful supply of water. If not near navigable water, get a location on a railroad switch, and if possible, near the water supply. If the two conditions cannot be fulfilled, you may make your choice between them, remembering that each additional handling of coal will cost about 10 cents per ton, and extra haul about 10 cents per 1,000 feet; and, on the other hand, that condensing your engines will probably save between 15 per cent. and 25 per cent. of your coal expense. The pressing necessity for locating near the lighting field has largely passed away with the introduction of long-distance systems of incandescent lighting.

Having determined on a location, the character of building to be erected must next be considered. The most important single condition essential to the success of the electric light business is continuous and reliable service to customers. The most disastrous calamity which can befall an electric lighting business, is the destruction of its central station. The first thing necessary to prevent such a calamity, is a building practically fireproof, and I believe a brick building best fulfills these conditions. Let the walls be bare, make all floors double planked and supported on iron beams, use no wood ceiling, however seductive it may be in improving the appearance of your station; leave as few openings as possible through the floors; have a nearly flat roof with fire walls projecting above, and the building will be as nearly fireproof as it can be, and at the same time fulfill the other essential conditions of insulation, and a reasonable expenditure of capital. Before leaving the matter of fire protection, let me strongly advocate the use of some good automatic sprinkler except in the dynamo room, and especially in parts of the building unoccupied during portions of the day, a stand pipe connected with your spare pump with nozzles on each floor, a few lengths of mill hose; a cask or two set in convenient places and kept filled with water and a few firepails near are cheaply provided, and the improvement in insurance rates will soon pay for them. At Troy, the reduction of rates has paid for the entire fire outfit in the saving in one year's premiums.

Before we design our station further, let me remark that the old adage that "cleanliness is next to godliness" would be a most wholesome motto for the electric light business. Dirt begets dirt, and with electrical apparatus it is by far the most fruitful source of short circuits, grounds, and consequently of burned armatures and disordered apparatus generally. Let us then so arrange our station that that most fruitful source of dirt, our boiler-house, may give us as little trouble as possible. Putting the boilers in the cellar and the engines and dynamos on the floor above is probably the worst possible arrangement next to putting all in the same room, since every opening in the floor conveys a blast of hot air, laden with coal dust and ashes. The correct method is to separate boiler and engine rooms by a fire wall, and make the only opening between through a room or passage through which a strong draft of air is always passing. This we effect at Troy by means of an air shaft 6 x 8 feet, which also serves as a wire tower and in which wash-sinks, etc., are also constructed. The doors, leading in both directions, are kept shut by heavy springs, and when opened the strong draft carries all dust, smells, etc., up the chimney. This shaft is carried above the roof, and the wires are carried out between the louvers of the blinds. One thing do not forget. Arrange a cellar or basement under your dynamo and engine room floor, about six feet deep. You will find it infinitely convenient in connecting small pipes, etc., to the under side of the floor.

Make your dynamo room not less than ten feet high for the comfort of your men, and arrange the windows to open clear up to the ceiling, as that is where the hot air will go to escape. You may also put your windows six feet above the floor, and you will save annoyance from spectators, and your men will not have so much looking to do.

The boiler house should be light in construction, having an iron roof with some outside covering, such as asphalt, to prevent sweating in cold weather. The boiler fronts should, of course, face either on an open lot or a street to facilitate handling boilers, and for the same reason the front of the boiler house should be easily removable. The floor should be of concrete, not less than a foot in thickness, made of the best Portland cement, mixed about 1 part cement, 3 parts sharp sand, 3 parts stone, broken to pass 1½ inch ring.

On this may be laid a floor of flags or arch brick laid on edge. No floor of cement or of ordinary brick will stand wear.

Going back to our main building, I will follow more particularly the line of work adopted at Troy. Our lot measures 50 by 130 feet, and the problem was to develop on that space a station of a maximum capacity of 500 h. p. effective.

The lot was occupied by a mere shed, covering two 80 h. p. boilers, located almost exactly in the middle of the lot; one 150 h. p. compound engine just beside the boiler, belted to 48 feet of jack shaft lying parallel with the length of lot, and two feet six above the floor, the dynamos lying each side of the shaft, the pull of the belts being nearly balanced.

The new station was laid out in a dynamo room, 50 by 90, and boiler house, 40 by 50 feet, arranged for a battery of four boilers, 72 inches by 17 feet, stack 13 feet square at ground and 125 feet above the grates; wire tower in corner between dynamo room and boiler house, projecting into the latter. As originally laid out, the engine stood in the new dynamo room close beside the fire wall, now separating engine and boiler rooms, and the boilers further out in the dynamo room. It was decided to build the unoccupied end of the dynamo room, put in engine power connected with the old boiler, shift the station, abandon the old engine temporarily, build the rest of the new station over the old, put in new boilers, then connect them and disconnect the old boilers, remove the old boilers, and finish the inside of the building. The company changed hands on May 23d, 1885, and on September 1st the old station was shut down at midnight, and the dynamos shifted to the finished part of the new building, and at six the following evening the station was in full operation in its new quarters. The plant then comprised about 600 Weston incandescent lights and some 20 arc lights. The remainder of the work was merely a question of time, and the station was first operated from its new boilers on December 17th, 1885. At the same time about 15 miles of pole lines were constructed, and some 30 miles of wire strung for the city contract of 130 lights.

The general construction of the Troy station is believed to cover the average conditions met with in central station construction, and is therefore particularized. In the arrangement of dynamos and engines, we desired to obtain the best economical results in the following items:

1st. Best average economy in coal.

2d. Best average economy in transmission of power to its work.

3d. Best economy of attendance.

4th. Best economy of oil, waste, etc. Our customers required a day service, and we had to take this into account in our selection of engines for power, and in their arrangement.

These conditions were to be borne in mind in the selection of our engines, and in addition, the most important condition of reliability. Compound engines offered us the best coal economy, with maximum load, but had the disadvantage of poor economy with light loads. Corliss engines would occupy too much room, and both required shafting and counters to speed up, and would have forced us to use the second floor for dynamos, with the attending disadvantages of extra help and upright belting. We finally decided on using the best type of high-speed engines, and purchased three engines of 9x14 cylinder, each belted to a jack-shaft, 16 feet long, and each driving four 110-light incandescent dynamos, belted in pairs from opposite side of the shaft. The lengths were arranged to be coupled by friction clutches. This arrangement gave us a very uniform rate of coal economy, thought not a very high one. The arrangement of belting made the shaft friction very small. The old compound was set to work on its proper duty of driving a fixed load of city lights.

The relative merits of compound, Corliss or high-speed engines are well understood, and the circumstances must in every case decide the type of engine proper to be used.

Where the maximum of output is required for a small space, high speed becomes a necessity. Where the load is very variable a number of smaller engines will give as good average coal economy as a single larger engine, with less chance of a complete failure. Where the load is heavy and constant, a pair of large engines will give the best economical results and at the same time cover the possibility of a complete breakdown. The new triple expansion engines, which are rapidly replacing all others in ocean and lake steamers on account of their wonderful coal economy, will probably displace all others in the field.

Condensing high-speed engines have not met with much favor; but we find at Troy that our "Straight-line" engines work quite as quietly under 28 inches vacuum as without, and that the coal economy is considerably improved; probably from 15 to 20 per cent. on the engines condensed. They have also the advantage of giving us much more power for cases of emergency.

As to boilers, I am strongly in favor of boilers of large size; ours measure 60″x17 feet and are of Nashua "Indian head" steel, $\frac{7}{16}$ shell, $\frac{1}{2}$-inch head, and have 136 3-inch tubes. The dimensions of the tubes 3″x17 feet would be out of all proportions for ordinary drafts, but our stack 125 feet above the grates gives us ample draft and the small tubes a great evaporating surface, and consequently a better evaporation. I am afraid I shall be considered a little unsound of mind when I state that with these boilers we are able, and do, evaporate with a mixture of one part bituminous to two of yard pea and dust, nine pounds of water per pound of coal, and with ordinary buckwheat coal ten pounds of water, feed water at 200 degrees. But such is the case, as I shall be happy to show any one visiting us. This is not pounds of combustible, but of coal. I have always found the ashes to cost just as much per ton as the fuel part of the coal, and therefore consider that they have no place in the relation of evaporation per dollar. We keep a daily and nightly record of our evaporation by a Worthington meter, which is on the boiler feed; and let me say that the bad reputation for veracity of meters in general will not apply to our meter, as repeated tests show a nearly constant error of 2 per cent. low. I may further say that our meter, though a Worthington, has no connection with the *Electrical Review*. I merely state this to protect the meter from undue suspicion.

For boiler feeds, provide a reliable injector in addition to feed pump, which latter should always be used in connection with a good heater. An extra feed pump may be connected as a fire pump, and should be used regularly for some such service as washing out boilers, to ensure its being in good order.

Attention to surface and bottom flues is, of course, a daily duty.

As to fittings, use some one kind of valve; get a good kind and stick to it. Price should have no place in the first choice of valves. Get a good one with moveable seats and discs and you will save a world of trouble and a deal—not an electric light deal—of money in a few years time. Let me remark that everything we have in bottom blow-offs has failed, except plain plug valves. The failure seems to come from scale, which will stick under the gates and seats, and bend them out of shape when closed. An extra large valve in the blow-off discharge is desirable in case of a failure of a blow-off valve.

In piping of all kinds discard elbows and use only T's, you will frequently save taking down an entire line of pipe to make some connection by so doing, and the T's are most convenient for examining and cleaning the pipes. You should also obtain all your fittings and pipe of one party to ensure good fits. Threading tools are seldom alike and a small variation will give endless trouble with leaks.

Cover all steam pipes, and remember, in choosing a covering, that it is not the material which you cover with, which makes the non-conductor, but the confined air spaces in the same. Get air spaces and get them so arranged that the air cannot circulate between hot and cold surfaces. Remember also that you can tell nothing by the feeling of the outside of a covering about its effectiveness. Sensations of heat and cold are intensified by the conducting capacity of the object touched. A piece of metal attached to a steam covering till hot will convince you of this. It can be no warmer than the covering, but it feels so.

In touching on the electric apparatus I feel that I am treading on delicate ground, and I shall try and step accordingly. The principal elements of ordinary wear in dynamos are

1, Burned coils in the armature; 2, wear of brushes; 3, wear of commutator; 4, wear of boxes or journals.

In regard to burned armatures, I will say that judgment should be exercised in the choice of a system as to the liability of such an accident, and this being determined, choose a machine whose armature is most readily repaired. Gramme and similar ring armatures are probably the most easily repaired. Siemens armatures and all armatures with lapped coils must go to the factory for a good job.

As to brushes, the cheapest by far both in first cost and wear, is the single leaf, split brush. Multiple brushes are usually used in commutators with many segments, and there seems to be some relation between the number of segments and wear of brushes.

Commutators of many segments are less desirable than those of few. The segments can usually only be changed by putting on a new commutator and they seldom wear true. The segments on commutators of fewer bars are usually arranged to be easily removed and can then be turned up and replaced.

Plain babbitted boxes or bronze bushings are about on a par for convenience in renewal. Bronze has the advantage of not being liable to melt out and cause a shut down, and a little patience will almost always succeed in cooling them down. For belting, probably nothing is better than double pasted leather belts if well made. For large belts a few rivets must be put in.

Arc lamps should be devoid of glycerine, and not easily shaken out of adjustment. The lighter and smaller lamps are, the better for handling. Arrange all inside wiring of some first-class high insulation wire, especially on high tension circuits.

In the Keystone station in Philadelphia I first saw oil conducted to each machine oiler and cylinder cup in pipes. I heartily approve this system as a saving both of oil and waste.

In conclusion, I will suggest two rules to govern central station construction.

1. Expend every dollar which will return 10 per cent. on its investment in addition to maintaining itself, including, of course, interest, taxes and wear and tear.

2. After carefully investigating, estimating and planning out the capacity of your station, make a large guess as to what you require, and multiply by two.

The Chairman:—A short discussion upon this paper will be in order. The subject seems to be such as to recommend itself to us all, and perhaps every body will assent to every thing that was said and will have nothing to add in the way of suggestion.

The next paper, as I understand, is on the change from negative to positive of the temperature coefficient of some carbon filaments, by Professor Anthony.

ON THE CHANGE FROM NEGATIVE TO POSITIVE OF THE TEMPERATURE COEFFICIENT OF SOME CARBON FILAMENTS.

Professor Anthony:—Mr. President and Gentlemen of the Institute: I am very much chagrined as I am obliged on this occasion to ask to be excused from reading a paper. We have been at work for some time upon this matter, but have only reached some results which I will give to you in a brief way, orally.

We have not so far reached anything upon which I could make out a written paper, so I will simply state a few facts that have been reached.

We found at first in the testing of a dozen incandescent lamps for the purpose of determining their efficiency, with paper carbons and filaments—we were simply making measurements for the purpose of determining the ordinary electrical efficiency of the lamps—we found that the curve representing the relation between potential and resistance ran like this (Figure 1); the potential being represented by the abscissæ and the resistance by the ordinates. Now, it had been my experience that the resistance of incandescent lamps or carbon filaments ran down when the potential ran up, and this was the first instance in which I had found an increase of resistance with rise of potential, that is, as the current and, of course, the illuminating power increased. In these particular lamps this change occurred very low in the temperature of the lamp. It occurred when in fact the lamp was only just barely red hot, and the resistance went on up to the limit to which the lamps were carried.

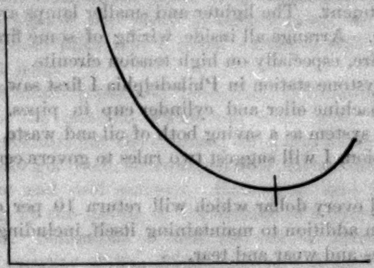

Figure 1.

Afterwards we thought this was of sufficient interest to pursue it in regard to other lamps. We have tested quite a number of lamps, and we have found in some four or five different cases, the same general results. Sometimes the curve does not change until we have reached the normal candle power of the lamp, and in many lamps we have tried, we never have reached any such change, the curve going on downward as far as the lamp could be carried, and in fact until the carbon began to disintegrate, in which case, of course, if we go back, and determine points as the potential is lowered step by step, the two curves will not coincide. We have found in some cases that the curve went down like this (Figure 1) and turned up as will be seen at the lower end of the diagram; but when we went back, we found our resistance was permanently increased on account of change in the character of carbon. But it is certain that in a number of different carbon filaments there is this change of resistance, and in all the carbon filaments that we have tried, except one or two, there is a change that indicates that at some point there would be a rise if we could carry the temperature far enough.

Now, what I hoped to be able to present to this meeting was the determination of something about the character of the carbon filaments, which showed the change early in the temperature of the lamp, where that change began at very low temperature, to determine the difference in the character between such carbon filaments; of the filaments which showed this change, and of those which did not show it and those which showed a continuous fall of resistance. That I have not been able to do. Furthermore, it was a point to determine the actual temperatures of the carbon. Those we have obtained with some degree of satisfaction; but I do not feel that our results are sufficiently trustworthy to present them.

Professor Thomson :—The observation of Professor Anthony is quite interesting to me, because one of our men reported, two or three weeks ago, the same phenomenon as noticed in lamps; that is, that at a certain brilliancy the resistance came to a constant and then began to rise as the brilliancy was increased. I told him at the time to pursue the observation a little further and let us have some better figures. He reported to us, that all lamps did not appear to do it to the same extent.

There is another curious fact which was noticed and which has been reported to me in regard to the resistance of incandescent lamps. We are building lamps that are run in series on arc light circuits using $6\frac{8}{10}$ and 10 amperes, and they are put in series with the arcs and give a candle power of 32, 65 and 125. We find that when these lamps are run for a certain time, during the early part of the run—for perhaps 200 or 300 hours of the run—the resistance steadily falls. After that, it seems to steadily rise. The lamps fall in the volts which are necessary to carry the normal current through them. It does not amount to a large percentage but continues during a large fraction of the life of the lamp and after that point the resistance gradually rises. Not only has this fact been noticed in regard to lamps of large candle power and with comparatively heavy filaments of low resistance, but it has been noticed that in lamps which have been run on arc light circuits in multiple groups, the same fall and gradual increase seems to take place, and it led us to imagine that there might be some connection between the peculiarities of the arc light current itself and this effect. We have not noticed the same effects on multiple arc circuits and we have not examined very thoroughly into the matter; but we have no reason to suspect, at least not now, that this fall and gradual increase occurs on multiple arc circuits; but it seems to occur oftentimes—not always—in lamps that are put on arc lighting circuits either in groups or in series, taking the whole current.

The following paper prepared by Mr. David Brooks was then presented by the Secretary.

LEAD-ENCASED CONDUCTORS.

BY DAVID BROOKS.

In the first attempt in this country to work electric telegraphy, by Professor Morse, the wires were covered with cotton, soaked in a preparation of shellac, drawn into lead tubes four together, the intervening space being left empty.

This system was laid from Baltimore towards Washington, about five miles on the Baltimore and Ohio Railroad. I got this information from Tatham and Bros., who made most of the lead pipe purchased, although none of what they made was laid.

The experiment was a failure. About that time, or a little before, Professor Jacoby, of St. Petersburgh, undertook to lay cotton-covered copper conductors in lead pipe with the intervening space filled with rosin. There have been very many attempts of that kind which proved to be failures, until the year 1856, when the discovery of petroleum brought paraffine into the market as a cheap commercial product. This was brought to my notice, and I made many experiments to test its insulating properties, and as the result, it was taken to the patent office, and the patent awarded me, broadly, for its insulating properties.

It occurred to me that cotton-covered wires could be drawn into lead pipe, and a useful system for underground purposes accomplished, but before rushing to the patent office, specimens were buried in the yard of my factory directly under a body of water, or earth soaked with water from a hydrant. These experiments were repeated, and for a long time were attended with failure. In the journal of the *Society of Telegraph Engineers*, published in London, we find accounts of similar experiments made there with like results.

Sealing the ends of a portion of this leaded cable, coiling it up, immersing it in melted paraffine, and raising the heat to about the boiling point of water, we noticed bubbles coming out apparently from the lead. Continuing this heat until all bubbles ceased to rise and then testing the cable, we found the insulation restored. The inference was brought to my mind that the coiling and the uncoiling of lead produced such molecular changes in the metal as to make it sufficiently porous to admit moisture, and the many unsuccessful attempts to lay lead-covered cables, when the cables were insulated with paraffine, in deep water, have served to strengthen this impression.

It must be borne in mind that paraffine, rosin, asphalt and other similar substances, in their normal condition, are brittle and the coiling and uncoiling of the lead pipe breaks them into innumerable small particles, which would leave the cable full of cracks or crevices.

These circumstances suggested the use of oil, and that brought out my system of iron tubes on account of their cheapness.

Lead covered cables are now successfully made by having the insulating material either rosin, asphalt, or pitch, mixed with oil in sufficient quantity to make the material plastic and capable of being bent without fracture.

Some of the inventors of these mixtures have repeatedly stated that their insulating material is a secret. Other materials are the subjects of patents.

Asphalt, rosin, or pitch, when mixed with oil sufficient to make them plastic but not to crack, is heavier than water, and thereby a great advantage is gained. Paraffine, either solid or liquid, is lighter than water. If solid, it cracks—if liquid, a drop of water penetrates it by reason of greater specific gravity of water.

In pursuance of the foregoing remarks, we must now look at the advantages of lead-covered conductors for all kinds of indoor purposes, or what are commonly called distributing purposes for electric lighting, etc.

An ordinary cotton-covered paraffine conductor for inside work is a dangerous thing. There has been sufficient property destroyed by the use of these cheap articles to pay five-fold the substitution for them of lead-covered conductors.

A lead-covered conductor, No. 18 gauge, may show an insulation resistance of 10,000 megohms per mile. When used for inside telephone purposes, if the lead-covering is attached to a gas or water pipe, there is perfect safety from fire from the electric current, should the outside conductor come into contact with an arc light conductor.

A copper conductor, No. 00, for arc lighting can easily be insulated when lead encased to 500 megohms per mile, and when that is brought into a building for distribution purposes, and the lead covering connected with a water or gas pipe, there is perfect safety from fire from the electric current, such as occurred at the Temple theatre in Philadelphia. Again, we can scarcely see how persons could be injured by the electric current conveyed through an insulated conductor covered with lead pipe, as was one of the employés of the Brush company in Philadelphia, who was killed not two weeks ago, and, since then, as another person was killed in the Adams Express building in New York.

Mr. I. N. Miller, of Cincinnati, has referred to several instances where people have been killed by taking hold of the electric light conductor covered with what is known as the underwriters' insulation, which is simply no insulation at all when exposed to dampness. As this insulation cannot be made to burn with a lighted match, it has been supposed to possess great elements of safety. But when it is encased in lead, and used for incandescent or arc lighting, a great portion of the current passes through the "insulation" to the lead covering.

Taking a piece of this underwriters' wire, covered with lead, and testing the insulation from conductor to covering with a current from a Holtz machine, you can produce no disruptive discharge, because the current passes through the "insulation" quickly, as fast as you can generate it by the machine. Take a similarly constructed lead-encased cable, properly insulated, immerse both ends of it in the insulating mixture and pass a current from the Holtz machine through naked conductors through the air, one pole connecting with the encased conductor and the other with the lead covering, a spark two inches long will pass between the two conductors in the air before any passes between the cas-

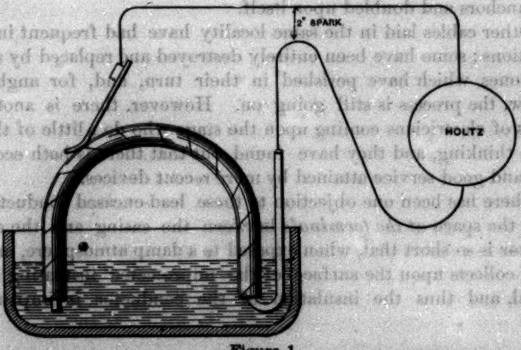

Figure 1.

ing and the conductor, although the distance through the insulation is only one-eighth of an inch. The object of immersing both ends of the encased cable in the insulating material is to prevent short circuiting through the air from copper conductor to lead covering at the terminals.

Much has been said of the incombustibility of the underwriters' insulation. But it is no more incombustible than the proper insulation, provided the spark is not exposed to the air. We can make a disruptive discharge through the insulation if it be too thin, but no combustion takes place, because the air is excluded.

We can now compare this insulation with gutta-percha, caoutchouc, and their compounds.

Exposed to the air, a lead-covered conductor will last ten times as long. Besides this, when running these seam-covered conductors around right angled corners, the insulating covering is apt to open upon the outside of the bend, while a lead-covered conductor will bear much rougher usage.

This quality has been demonstrated by a lead-covered cable for telephone and telegraph, armored with iron wire, and laid across the bottom of the river Delaware between Philadelphia and Camden seven years ago, where it has worked without interruption or deterioration for all that time, although occasionally hooked up by anchors and doubled upon itself.

Other cables laid in the same locality have had frequent interruptions; some have been entirely destroyed and replaced by similar ones, which have perished in their turn, and, for aught I know, the process is still going on. However, there is another class of electricians coming upon the stage who do a little of their own thinking, and they have found out that there is both economy and good service attained by more recent devices.

There has been one objection to these lead-encased conductors, that the space *at the terminals* between the casing and the conductor is so short that, when exposed to a damp atmosphere, moisture collects upon the surface of the unprotected insulating material, and thus the insulation of the conductor is impaired.

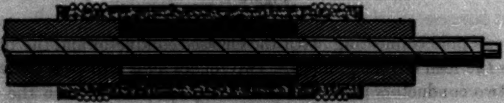

Figure 2.

Messrs. Tatham and Bros. have a simple device by which that difficulty is completely remedied. A short section of the lead casing is cut out some inches from the terminal and an India-rubber sleeve slipped over the gap, and over both parts of the lead pipe remaining. Both ends of the sleeve are then tightly bound to the lead pipe with twine, and the insulation of the cable is safe from moisture.

ADJOURNMENT OF THE GENERAL MEETING.

THE PRESIDENT:—I think we have all had a day of great pleasure and profit, and we shall go to our regular daily duties refreshed and benefited and better able to do the work that lies before us. There being no further business a motion to adjourn is in order.

On motion of Mr. Mailloux the meeting then adjourned.

Special Meeting.

June 28th, 1887.

The meeting was called to order at 8 P. M., at Martinelli's, 136 Fifth Avenue, New York, by the President, Mr. T. C. Martin, who announced the subject for discussion as Electric Train Lighting, and introduced Mr. George W. Blodgett, Electrician of the Boston and Albany Railroad, who had prepared a paper for the meeting.

Mr. Blodgett:—Mr. President and Gentlemen; I highly appreciate the honor you have done me in asking me to read a paper upon this somewhat new and important subject of "The Electric Lighting of Passenger Trains." It is to me, to some extent, an unsolved problem still to be worked out, so if you should say to me at the end of my paper, you are not well informed upon the subject, I should feel like saying, neither are any of us. It is in some points at least a subject of which we all know very little.

THE ELECTRIC LIGHTING OF PASSENGER TRAINS.

BY GEO. W. BLODGETT.

A better method of lighting passenger trains is demanded by considerations of economy, comfort and safety. Economy is a question which chiefly concerns the railroad management, but comfort and safety concern all its patrons. There are two ways in which we may seek these; either by improving the present system or by substituting a better one. It is doubtful whether oil lighting can be much improved and still be reasonable in cost, and whatever danger attends its use would probably still remain. I have made careful inquiry among my railroad friends without finding any instance within their personal knowledge where the ruins of a railroad wreck were set on fire by the lamps in the train (indeed these are usually instantly extinguished), but such an instance was said by one of the survivors to have occurred in the late disaster at Hartford, Vt., and another was mentioned at a recent meeting of the New England Railroad Club, where the explosion of a lamp set a sleeping car on fire, and it burned with nearly all the occupants. It is, however, certain that a pile of splinters deluged with oil will burn more fiercely and be much more difficult to extinguish, than if in its normal condition.

It is therefore desirable to get rid of oil lamps, for the harm they may do in *aiding* the progress of a fire, even if they do not cause one. The discomforts of oil lighting, in point of amount, distribution, unsteadiness and color of the light, corruption of the air, and the great heat given out by a large number of lamps in a car are other reasons why a change would be welcome to both the railroad management and the public, if a reliable substitute can be found. Some of the objections enumerated above apply with equal force to lighting by gas, the others are partially, but not wholly eliminated. *Electricity*, however, offers a means of lighting which comes nearer to meeting all the requirements of a perfect light for passenger cars than any other yet discovered.

There are several ways in which we may produce the electricity for car lighting. It is possible to light a car successfully by any one of them, but further experiment is necessary to determine which is the very best to adopt, and we have already found some much better adapted than others to our American trains. The different methods will be considered in order.

1. By batteries. I know only one experiment successfully going on at present. A train has been running for nearly a year between Paris and Brussels, the cars of which are lighted by electricity from a bichromate battery. It lasts for five trips of seven hours each—that is, 35 hours of lighting—without renewal, which is said to take only five minutes. No accurate estimate of cost, or more detailed information is yet at hand. There are several other batteries in the market which appear well, and if the motion of the train does not have a deleterious effect, would seem possibly adapted to this work. My own experience is conversant with only one trial of this kind which did not succeed. Forty cells of a battery which had worked well in several house installations were put in boxes suspended from the bottom of a car, and 16 lamps of 16 c. p. each, put up in the car. The lamps burned well for one night, but the next night there was the appearance of a sudden and enormous increase of internal resistance in the battery, and it was removed for further experiment before trying to light cars. An attempt was made two or three months ago, to light a

N. Y. C. passenger car with batteries of some kind, which also failed as I am told. [Note A.]

2. By a dynamo machine. There are three ways in which this has been done. A small dynamo and engine have been mounted on the boiler or tender, and the latter run by steam from the locomotive boiler. The great objection to this method is that there is no light before the engine is attached to the train, nor if it be temporarily removed. To obviate this difficulty a separate boiler, engine and dynamo have sometimes been carried in the baggage car or on a platform car at the head of the train. It would seem that the danger from fire in this arrangement would be quite as great as by the stoves in the cars. A method tried with some success in a few instances in England and elsewhere abroad (but only once in this country to my knowledge), is to run the dynamo from one of the axles of the train, the proper speed being obtained by suitable countershafting and belts between the axle and the pulley of the dynamo. Since there would be no light when the train is at rest or when the dynamo was running at too low a speed, a battery of accumulators is added, sufficient to keep the lamps lighted for the longest time when the train is standing in the station, or elsewhere. When the train stops, or is at too low a speed for the dynamo to light all the lamps, they are automatically switched to the circuit of the accumulators where they remain till sufficient speed is again attained when they are switched back on the dynamo circuit. During the day, when the train is running, the dynamo charges the accumulators and keeps them full. They are sufficient to light the train several hours if need be. On one train, in Germany, the dynamo and 26 accumulators weighed 1,350 pounds, and cost about $625; operating about twelve lamps, cost about two cents per hour, or one-sixth of a cent per lamp per hour. The London, Brighton and South Coast Railway Co. fitted up four trains in this way. In one train of eleven cars there are thirty-two 16 c. p. lamps, absorbing forty amperes of current. The accumulators are stated to hold 500 amperes (probably 500 ampere-hours is meant), and

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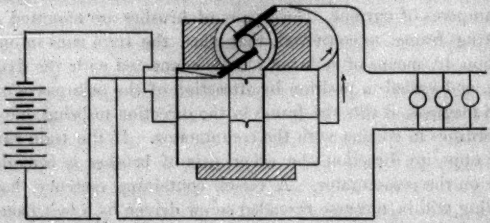
NOTE A.—Most batteries furnish a continuous current for so short a time without renewal, that their use is debarred on this account. Some others will not bear the shaking up produced by the motion of the train. I have myself experimented for a considerable time, but thus far without finding a battery which will run on a closed circuit longer than two or three weeks, and at the same time can be carried on a train. When such a one can be found, which at the same time gives a current strong enough to light a series of lamps, it will have a great field of usefulness.

when fully charged are stated to be sufficient to maintain the lamps for eight hours. This train has been running since December 19th, 1883; during the first eleven months it made 2,352 trips, and ran 27,322 miles. No failures are reported. A train on the South Eastern Railway has even run a longer distance. The dynamos on these trains have an E. M. F. of 45 volts and give 56 amperes of current. Two pairs of brushes are mounted on a rocking frame, so contrived, that when the train runs in one direction, by means of a lever loosely connected with the dynamo axle, and varied in position by attraction of the pole pieces of the field magnets, it tilts the frame in the direction to bring one pair of brushes in contact with the commutator. If the train runs in the opposite direction, the other pair of brushes is brought to bear on the commutator. A vessel, containing mercury, has revolving within, a coarse threaded screw driven by a belt from the dynamo-axle. At each end of the vessel is a vertical tube, at the upper end of which is an adjustable contact screw. When the dynamo and, consequently, the screw revolves in one direction, the mercury rises in one tube. If the motion is reversed, it rises in the other tube, and when it makes contact with the adjustable screw, the shunt circuit of the dynamo is joined up, the field magnets are charged, the lever is drawn up, and one pair of brushes brought to bear on the commutator, which completes the circuit for charging the accumulators. When the lamps are lighted and the train is in motion, the dynamo feeds them, the accumulators merely acting as a regulator. If more current is being generated than the lamps require, it goes to the accumulators. If less, the balance is given out by them. When the speed of the train slackens, the fall of mercury in one of the tubes breaks contact with the adjustable screw, the field magnet circuit is broken and the brushes are removed from the commutator, the lamps continuing lighted by means of the current from the accumulators.

The apparatus can be used for several weeks with no attention beyond lubrication, and at the end of this period only a re-adjustment of the commutator brushes is necessary, which puts the machine in condition for a like longer period. The weight of the apparatus is about two tons.

The connections between the cars are made by coupling two cables together. A slightly different arrangement of circuits has the field magnets of the dynamo wound with two wires in opposite directions, one of which is in shunt to the armature, as if the dynamo was an ordinary shunt machine. The other is wound in the reverse direction, as if the dynamo were a compound machine, and the accumulators are in series with this wire. The lamps are also in shunt with the armature.



There is a cut-out to break the circuit of the armature when the dynamo runs below a certain speed; this prevents the cells discharging themselves through it and burning it out. If the dynamo does not furnish current enough for the lamps, the accumulators supply the balance, and in doing so, strengthen the field magnets and cause an increase of current in the dynamos. When this reaches a greater amount than that needed by the lamps, the surplus goes to the accumulators, and at the same time decreases the magnetism in the field magnets so as to preserve the balance. At the maximum speed of the machine, the cells are receiving their maximum charge, and the current to the lamps is of normal amount. Two sets of brushes are here necessary, as in the other case. Mr. Barrett, of Springfield, Mass., has fitted a train of three cars on the Connecticut River Railroad, with electric lights, to be run from a dynamo in something the same way as these just described. The peculiar arrangement of the trucks under an American car renders it a matter of difficulty to obtain the proper speed of the dynamo, and I am told Mr. Barrett has had much trouble with the connections between the axle and counter-shaft. If these are not kept tight the cable slips. If too tight it breaks. An ingenious device like a friction clamp transmits the power from the counter-shaft axle to a pulley upon it. This is governed by centrifugal weights balanced by stiff springs. When the dynamo runs at its normal speed these just balance the friction of the clamp and there is no slip. Any increase of speed then causes the friction to diminish, and the pulley slips upon the shaft, till equilibrium is restored. Twenty-four Julien accumulators are connected with the circuit as a regulator, and to keep the lamps lighted when the train stops. A centrifugal governor breaks the circuit of the accumulators when the speed slackens.

A third arrangement of electric car lighting is by accumulators on the train, to be charged by a dynamo at a central station or terminus of the road. In England, a Pullman train has been running some years, lighted by electricity supplied by accumulators charged when the train is at rest, by a dynamo driven by a gas engine. The Pennsylvania Railroad Co. experimented more than two years ago with accumulators charged at one end of the line. When the train arrived at Jersey City, the trays containing the cells were removed from the car to a charging room, their places being supplied by spare cells previously charged. The empty ones were charged, to be replaced in the first car needing its batteries changed, and these in turn to some other car. The changing of the cells in a car took about 10 minutes. These experiments were in the main satisfactory, but the weak point was the life of the cells, the plates of which after a time buckled and fell to pieces. These cells were furnished by the Brush Electric Co. for these experiments; but they declined to send out any more to be used in the same way until the Pennsylvania railroad experiments should be ended.

The estimated cost of fitting a car with ten lamps and batteries for 70 ampere hours was about $300 per car.

In the month of January of the present year, the Julien Electric Co. placed 60 cells of their accumulators in boxes, on car No. 90 of the Boston and Albany Railroad, and put ten 16 c. p. lights in the car. These proved to be insufficient and the number was afterwards increased to 24, of which 20 were on the car and four over the platforms. This car was run some two months, as an experiment, with such excellent results that in March and April the trains leaving Boston and New York at 4:30 P. M. every day were fitted up with the same system. (These trains are also heated with steam from the locomotive, and there are no fires or oil lamps in any of the cars.) Each coach and parlor car is fitted with twenty-two 16 c. p. incandescent lamps, of which two, are over the platforms, 16 in the body of the car and the rest in the vestibules and toilet rooms. The lamps in the car are arranged opposite each other in two rows in the top of the car, and are on two circuits entirely independent of each other, each of which has a switch of its own by which the lamps may be turned on or off. The platforms are so arranged as to be lighted from either end of the car. They may, if desired, be lighted only just before reaching a station and extinguished just after leaving it.

Sixty cells of Julien accumulators are arranged in boxes under the car, 30 cells on each side. The weight is about one ton. The boxes are neat and ornamental in appearance, and the 30 cells on each side of the car are entirely independent of those on the other side, and are separately wired as far as the switch-board.

The cells have a capacity of 150 ampere hours and 60 volts on each side of the car. As 60-volt lamps are used, the accumulators on either side of the car will run all the lamps, but of course for only half the time the whole will do it. They are arranged in trays of six cells each, furnished with handles; they weigh 200 pounds and can be raised from the ground and put in the car by two men. The trays are fitted on the outside with stiff brass springs, which, when the trays are in place bear against each other, and form the connection between each tray and the next. When the trays are in place in the boxes the connections are all made. There are, therefore, no wires to disjoin or connections to make when it is desired to remove a tray for examination or otherwise. From the boxes on each side of the car, wires are carried underneath the car to a switch-board in one of the toilet rooms, which also receives the terminals of the lamp circuits. The switch-board is so arranged that the number of cells in use can be varied from 27 in series to 30 in series, the others being added from time to time, to keep up the candle-power of the lamps, as the E. M. F. of the cells falls. Experiments are now being made to do away with the necessity for this, and if it is found practicable, it will be discontinued.

Two terminals underneath the middle of the car on either side serve to connect, by means of plugs, a pair of cables connected with wires leading to a dynamo in a lighting station a little way off. These terminals are of different size, so that no mistake can be made in the connections. When the accumulators are charged the whole 60 cells are placed in series; when they are connected to the lamps there are two series of 30 cells coupled together. In order that there should be no confusion or errors in doing this, I designed a switch which should, by a single movement in one direction, of four levers coupled together, throw all the cells in series and connect them to the dynamo circuit. In this position they are entirely detached from the lamp circuits and no current can pass to the lamps. When this switch is thrown in the opposite direction the cells are cut off from the dynamo, coupled in two series of 30 cells each, and connected to the lamp circuits, which, however, do not light until turned on by the special switches for that purpose.

It is quite unlikely that an accident to either of the lamp circuits or the batteries on one side of the car would disable the other. By turning out the lamps on one circuit, therefore, the others may usually be kept burning till the train arrives at its destination. In two instances this arrangement of circuits has proved very valuable.

All the cars, except one, are fitted with Weston incandescent lamps said to take 1.1 amperes. The remaining car has Edison lamps, which are proving so satisfactory that it is quite probable all new work will be equipped with the Edison apparatus.

When the train arrives at Boston, it is put on a side track near which a line of poles has been set, and the dynamo wires strung upon them. Opposite each car a pair of terminals serves to make connection with the car, and the charging begins. A current of 18 amperes is run in for several hours, dropping to 12 and sometimes 10 amperes towards the end of the charge, which is now 180 ampere hours, to the 60 cells in series. If there were no loss, we could draw out 360 ampere hours in the lamps. Assuming that the lamps use 1.1 amperes each, we actually use about 22 × 1.1 ampere × 9 hours = about 216 ampere hours or 60 per cent. of what is put in. If the lamps are required an extra hour or two, there is plenty of reserve for them. [Note B.] The attempt was made to reduce the charge to 140 or 130 ampere hours, but as some of the batteries were not in first-class condition, the results were not good.

The intention is always to have surplus of current in the battery. For the present the trains run a round trip to New York and return with one charging, but it is not yet quite certain that it can be done in the long nights of winter.

NOTE B.—Mr. A. Reckenzaun in a recent article on storage batteries gives the average efficiency as not less than 70 per cent. The Julien company claim, I understand, 80 to 85 per cent. for theirs. Doubtless this can be realized under special conditions, but my own experience would not warrant me in assuming so much in car lighting,—at least until the most favorable conditions of use are better understood.

The cost of fitting these cars with accumulators and lamps was, when complete, about $900 per car. Others fitted in the same way would cost less, as on this work the men were all inexperienced and there were no plans or precedents. The cost of operating the lights is not far from $2 per car per day, or about one cent per hour per lamp. When the lights are needed a longer time, as in the dark days of winter, the cost per lamp hour would diminish. This is about ten times that of oil, and very nearly the same as for gas, but taking into consideration the amount of light obtained, electricity is the cheapest of the three, and immeasurably the most convenient. The light is very brilliant, well diffused, steady, and satisfactory beyond all expectations. A very noticeable feature of these cars is, the entire absence of heat, and the purity of the air, which is as fresh and sweet in the car at the end of its trip as before it leaves the first station; this, together with the absence of danger from fire, especially commends it for sleeping cars. The Electrical Accumulator Co. have also lighted some cars with success, for the Fitchburg and Old Colony Railroads, at Boston.

The electric light has come to stay. It is the only one which anywhere near fills the conditions of a satisfactory light for railway trains. It can be readily adapted to almost any conditions to be met with in practice.

Oil lamps, and stoves in cars, must follow where the old couplers and hand brakes for passenger trains have gone in this country, until electricity and steam heat have made the roasting alive of scores of people pinned fast in a railroad wreck as impossible as the air brake and Miller platform have made the telescoping of a train into a shapeless mass of ruins, as happened formerly so often. Not many years hence, we may well hope, one will be as uncommon as the other.

DISCUSSION.

THE PRESIDENT:—The paper is now before the meeting for comment, criticism and discussion. Mr. Blodgett has had, as you have heard, very practical experience with the work and will be happy to answer any questions which may be put to him in regard to any of the details.

THE SECRETARY:—I had the pleasure of coming from Boston, a week ago to-night, in a train equipped with the system which Mr. Blodgett has described so successfully, and having in view the fact that this paper was to come before our meeting, I perhaps gave the lights more attention than I otherwise would. The first and most noticeable feature of the installation to my mind was the fact that it appeared to be permanent. It was not experimental in the sense that so much electrical lighting has been, which we have all seen. Wires may have been there, but they were not visible. The lighting of the cars was certainly the best general lighting that I have seen with the exception, perhaps, of the Electrical Exposition at Philadelphia. The cars were lighted up in the station before leaving Boston at 4.30 in the afternoon, as it was rather dark in the building at that hour. That was the first advantage I saw. Although early in the summer afternoon, when artificial light is usually unnecessary, it was very easy to turn the lights on to give good illumination while the cars were temporarily in the station. After leaving the station, they were turned off, not being required again until nightfall. I think we reached the darkness about Hartford, and not having the scenery to gaze on, I turned to a book I had with me, and was very much pleased to find I could pass the time pleasantly with reading, without any strain on my eyes; and one curious feature of it was that, being absorbed in my book and having been looking out of the window for three or four hours, I turned once or twice to look out, and was surprised to find it was dark outside; there was nothing to look at. I had almost lost sight of the fact that it was artificial illumination, and this was certainly a very pleasant feature to think that I could read by a light as perfect as daylight, and possibly more perfect than some daylight that is quite common on the other side of the water. The lights are turned on in going through tunnels, or when you come to dark stations, which I consider a very desirable feature. The element of safety is one that is particularly noticeable, because we have heard so much of the dangers of fire from electric lighting. Now, however, when it comes to requiring safety from fire on railway trains, our experts turn to electric lighting, as the only resource; and there is no doubt but that danger from fire is entirely eliminated by the use of incandescent lights from storage batteries as they appear on that line. I am contrasting the wiring of this installation very favorably with another installation of car lighting which I saw on the same trip, where the wiring in both baggage and passenger cars bore evidence of having been done by some bungling telegraph lineman who had just started in the business. The expense the Boston and Albany Railroad Company has incurred in introducing these improvements reflects a great deal of credit on the progressive management of that road.

THE PRESIDENT:—I would like to ask Mr. Blodgett a question. You stated in the course of your paper, Mr. Blodgett, that the cost of electric lighting was ten times that of oil. I would like to have it specifically stated, if you can do so, whether that applies to the whole of the apparatus or simply to the service.

MR. BLODGETT:—My figures in relation to the cost of oil lighting were taken from a report by the Master Car Builders Association—possibly ten years ago. My impression is that in this report they took into account only the actual consumption of oil for lighting, and that no account was made of the cost or the care of the lamps or their renewal, or anything of that kind. Their figures show that oil lighting costs about one-tenth of a cent per hour. As near as I can estimate from our own experience with electric lighting, it is not far from one cent per hour, which would be, roughly, ten times the cost of oil lighting, not counting the cost of the renewal of the plant, or as my impression is, the cost of repairs to oil lamps—I am not certain about that.

THE PRESIDENT:—As I understand, the cost of electric lamps in a car is materially less. I am speaking of the lamps themselves. Is not that the case?

MR. BLODGETT:—The fitting of the car with oil lamps, will cost anywhere from $12 to $50 for each lamp, and if, as is usual, from twelve to fifteen lamps are put into a car, it would cost not less than $150 for the oil lamps put in a car. The cost for an equal number of electric lamps would not be over $24.

MR. PHELPS:—May I ask Mr. Blodgett, in making up the figures of cost of electric lighting, if he first entered the item of depreciation of the storage battery plant—its consumption?

MR. BLODGETT:—It is difficult for me to estimate to just what that would be. The assumption was made that the batteries would last two years.

MR. PHELPS:—Then your figures proceed on that basis, the renewal of the batteries in two years?

MR. BLODGETT:—I think that was the estimate; renewing them every two years. I ought perhaps to say, regarding these figures, that the time during which the apparatus has been operated, is so short, that the figures are only roughly approximate. The cost may prove to be very much less than this, and possibly, but not probably, is seems to me, somewhat greater.

Mr. Ries:—What proportion of the cost for lighting is due to the cost of handling the batteries, and what proportion is due to the interest on the installation?

Mr. Blodgett:—There is no expense for handling the battery. The charging of it has been done thus far at the rate of seventy-five cents per car per day. I think it will cost somewhat more in the future, as the electric lighting companies who are doing it, complain that this rate does not pay the cost. Possibly it may cost $1.50 a day per car for the charge.

Mr. Ries:—According to that, the cost per lamp simply for the charging, would be about five cents?

Mr. Blodgett:—Roughly that.

Mr. Bracken:—I can state that the cost of charging Julien cells per car is about thirty-three cents. The Weston Company charges one dollar and a half per car. I may say here that about six or seven days ago I met Mr. Pullman. I remarked, among other things, that the chief objection to lighting railroad trains by electricity seemed to be the expense, and he said—of course it was his opinion, but it has considerable weight, coming from a man of his experience—he said that the mere matter of expense would not stand in the way of ligthing by storage batteries, if it were proved to be practicable. Then we have the opinion of another gentleman who has had a great deal of experience, Dr. Dudley, of the Pennsylvania Railroad. Two years ago, that road experimented with storage batteries. Dr. Dudley has come to the conclusion, as a result of his experience, that the only thing now wanting to induce the Pennsylvania road to adopt the storage batteries was a simple connector of a cell whereby a plate could be removed which showed any disposition to deteriorate. So far we have been unable to get a connector that we could remove and adjust without considerable trouble in order to remove a defective plate. The chief objection made by parties in relation to lighting by storage batteries is the fact of cost—the first and the only objection; but experienced railroad men, as I have told you, do not seem to regard that as a serious objection any more than is the cost of a parlor car in comparison with an ordinary passenger car.

The Secretary:—I would like to inquire whether the objection to the expense is on account of the original cost of the plant or the cost of the running of it, after it is installed?

Mr. Blodgett:—I think, Mr. President, that both those arguments have been used as an objection to the introduction of electric lighting; but if account is taken of the amount of light furnished by the electric light in comparison with gas or oil, that item of expense will disappear. If people will be content to have as little electric light as they will get from oil or gas, the expense, it seems to me, would be no greater, but the change in lighting is the excuse for getting three or four times as much light as is furnished by the old systems. In that respect the cost of electric lighting is made to assume a very undue proportion in relation to the cost of other methods of illumination, and there, it seems to me, is a very prominent reason why the electric light fails to make greater progress—that with the change, is demanded an enormous increase of light.

MR. LOCKWOOD:—Mr. Blodgett, among other statements in his paper, remarked upon a method of introducing first, only a comparatively small number of cells, and as exhaustion supervenes in those cells, a few more are introduced, and then a few more. I would like to ask him whether experience has demonstrated that to be a better method than introducing the full number of cells at first and with them a certain artificial resistance, and then switching out the resistance as occasion would demand?

MR. BLODGETT:—I would say in answer to the question that the number of cells was never varied more than four on each side. We started with twenty-seven cells in series and ended with thirty in series. We have run trains on trips with the whole thirty cells in series, and I might say with substantially the same results. There was no opportunity for me to determine by experiment, previous to running these trains, any of the questions which have come up in relation to it. The electromotive force of charged cells is rightly two volts, but when they are freshly charged it is somewhat more than that; I think some of the publications on the subject state it at 2½ volts. In order not to have the undesirable effect of burning out a number of lamps by running a greater current than they would bear, this arrangement of switches was made. Thus far we have no unfavorable results. In one or two instances, when that was tried, it did seem to me as though the lights were not quite so good at the end of a trip as when we had started with twenty-seven cells in series, and four remaining cells to be put in from time to time, as the candle power of the lamps began slowly to diminish; but I am not prepared to speak decidedly on that question either way.

MR. LOCKWOOD:—Does not the resistance of the cells vary as their E. M. F. runs down?

MR. BLODGETT:—I think that is probably true.

MR. LOCKWOOD:—That is the point I was trying to get at, as to whether it was a decided advantage to keep those cells included in the circuit, even though they were to a certain extent exhausted, and even though you got the benefit of the new cells by so doing.

MR. BLODGETT:—I think further experiment is necessary in order to enable one to answer that question.

MR. MAILLOUX:—I think I can give some information on that subject to Mr. Lockwood. I hardly think the question needs to be answered, because probably everyone who has experimented with primary batteries, knows that you can take freshly charged bichromate cells—say Fuller cells, and if you wish to make a constant difference of potential across a certain part of the circuit you can use a part of them at first, and as they weaken add more to the circuit. The only difference that it makes, as far as I know, is that you are adding cells which have not been worked so much, and they would not give out so quickly as the others. In others words, the number of ampere hours that would be obtained from these freshly added cells would not be so great, and in practice, using them, as Mr. Blodgett states, those cells that are added last are never discharged to such an extent as the others, consequently there is some energy left in them at the end of the trip. It would doubtless be practicable to use resistance as Mr. Lockwood suggests, and to discharge the cells, but there would be nothing gained by it, except, perhaps the inconvenience of handling the resistance. It is much simpler to use only those cells which are necessary to get the proper electromotive force, and to add cells as the electromotive falls down; and those cells which are put in last if they are not fully discharged, are in much better condition because we find in working storage batteries that it is not well to charge a storage battery too much. Indeed, I may say that the greatest grievance we have against storage batteries, is that the public will insist on trying to give to the storage battery a greater capacity than the maker himself would like to have it go out for. The Julien Battery Company, with whom I have the honor of being associated, makes a cell of one hundred and twenty-five ampere hours, which is catalogued for that rate; but we find numerous people who have endeavored to use it for street car traction and for various other purposes, and who have come to us telling us that they get from 180 to 200 ampere hours out of the cells, thinking they were giving us very valuable and much coveted information. But while we admire their enterprise, at the same time we always deem it prudent to tell them that they really need not fully exhaust their cells, that they had better restrict them to the capacity which the manufacturer denotes. We tell them, if they persist in using a 125 cell to a capacity of 180, we shall have to rescind the guaranty of two years that we give upon a cell. The fact of the matter is, that there is an intimate connection between the life of a cell and the way in which it is handled by the person who buys it, and, as I just said, the trouble comes mainly from the fact that the cells are over used. It is not the use of the cell, but it is the abuse of it that is always responsible for its giving out. As long as a cell is not fully discharged, the peroxide on the positive plate is to a certain extent infiltrated with sulphate that has been produced by the chemical reaction during discharge. But if we proceed so far that a large quantity of sulphate becomes formed at the expense of the peroxide, then we shall find that when the process of discharging is again resumed, that we can no longer reconvert that mass of sulphate into peroxide, and wherever the process of charging is stopped, there will be a process going on by which that sulphate will undergo a fresh reaction and become hardened, and the consequence will be that a line of demarcation is produced and a scale results. That scale is the beginning of trouble and a great many times the beginning of the end with a great many storage batteries. This is a defect which is inherent in a great many storage batteries using lead. Now, if we do not discharge the battery too much, we leave a sufficient mass of peroxide to add conductivity to the mass of sulphate, so that the process of discharging can proceed without difficulty. That is why it is more difficult to use the three or four cells which are added, and which are necessary to rejuvenate the force of the rest than to discharge them all equally. Those three cells are not discharged so much as the others, consequently they are not so much used, and, by the process of changing the trays once in a while, so that they all have this little holiday at the end of the trip, the amount of life thus given to the battery could be averaged through the whole number of them.

Mr. Wetzler:—Mr. Blodgett, in his paper, enumerates the different methods by which trains may be lighted, and in all of them except one, in connection with which he mentions the primary battery, we find that where we want a steady light the storage battery must be added to the equipment. Although he says he has had experience with only one of this kind, I would like to ask if he has formed any opinion upon the ultimate shape which the application of the storage battery will assume—whether it will be charged on the train or whether it will be charged at the terminus only.

MR. BLODGETT:—That is rather a hard question to answer, since it must be on my part merely a matter of opinion. It does seem to me, however, that some one will find a way by which the battery can be charged on the train with regularity and with good results. If that can be done, it will much simplify the use of the storage battery, since the charging will take no extra time, and would, it seems to me, give better results than being obliged to charge the batteries every day or every other day. I know of no practical device at present to accomplish that result. Its success in England is due to the different arrangement of the cars. Most of the English cars on which it has been tried, have, in place of our trucks at either end of the car, only a single axle and a pair of wheels which are fixed with sufficient rigidity, so that they can run a dynamo shaft. But American cars have a swinging truck at each end from which it is difficult to convey power to any other piece of machinery while going around curves.

MR. RIES:—Mr. Wetzler has asked almost the same question that I was about to propound, and Mr. Blodgett has answered it so far as the present state of knowledge is concerned. But the feature that Mr. Blodgett just mentioned: namely the difficulty of making connection between the axle and other mechanism is, of course, one of those difficulties which only time can overcome. But it seems to me that instead of taking a secondary battery, instead of equipping in such a way that the battery must either be removed from the car, or that the car must be side-tracked and remain idle for eight hours more or less, a system could be devised in which the battery carried by the car was a permanent fixture and received its charge during the time that the train was running on down grades by a dynamo, driven by the surplus energy of momentum of the train itself, whereby the direct application of steam co-operating with the dynamo can be obviated. One of the greatest objections to these various steam heating systems, is that in order to maintain a separate system of heating, the locomotive would have to be drawn upon very considerably, and that is found somewhat impracticable. The very same objection would obtain in the use of a battery; but on large trunk lines, there are numerous trains in which it would seem that the momentum which is in excess of the speed at which it is desired to run could be readily converted into chemical energy, which could be stored in a battery until required. It might be so arranged as to receive all the current that is generated at regular intervals, and in a simple way this could be made to furnish the current for lighting. Several of the members here would be pleased to know whether Mr. Blodgett has had any experience with such system, or whether he knows of any such system being proposed for utilizing the electric current for lighting railway trains.

Mr. Blodgett:—I do not, Mr. President, know of any such system. It seems to me that the amount of power required to light a train electrically is so very small that it would not be a serious question. If the locomotive is so nearly worked up to its full capacity that it could not spare two or three horse-power more when running between six hundred and seven hundred perhaps, or possibly eight hundred or nine hundred horse-power, if it could not spare two or three more for lighting the train, then it would be necessary to attach a second locomotive to keep up the speed of the train around the curves. The belief that the heating of the train would make a draft on the locomotive has been brought up as an objection, but practical experiments have failed to show that steam heating does have such an effect. The amount of steam heating required for a train is very small, and the pressure of two to five pounds even in very cold weather with proper piping of the cars and proper connections, will sufficiently heat the train, and when the locomotive carries 160 pounds steam, as the best kind of locomotives do, a pound or two more is not a serious percentage of loss.

Mr. Lockwood:—I am very happy to add my little word of testimony to that of Mr. Pope, as to the efficiency and perfection of the system of electric lighting which now obtains on the afternoon train, between here and Boston. It is some three months since I first travelled on that train, since the lighting and steam heating was introduced, and although I had heard it vaguely referred to in the papers, I had not experienced it myself before that; and it was with considerable doubt that I took my seat on the train that afternoon. Mr. Pope has remarked upon its advantages in going through tunnels. I must say, there is room for difference of opinion in regard to that. But as there are not many tunnels between here and Boston, it is not much of an objection nor much of an advantage upon that line, but it is a real pleasure to any one who likes to read upon the train, or who likes to see what his fellow passengers are doing, or who likes to eat intelligently, to travel upon a train lighted with incandescent electric lamps excited, not necessarily by a Julien battery, but by any good secondary battery. I notice with some grief that the gentlemen here have been persistently calling such batteries accumulators and storage batteries. There perhaps may be a word or two which might pertinently be said referring to the English installation, which Mr. Blodgett has mentioned. The system which is in use on the London and South Coast Railway is, as as we have heard, operated by the shafts of their cars, and, as Mr. Blodgett has said, they do not use trucks at all, simply a pair of wheels on each axle. The method of getting the power to the dynamo is by using an counter-extra shaft and running two belts. That is a point worthy of notice—a pulley on each side of the train, running two belts to the counter-shaft, and although it was not done so at first, they have recently adopted also two belts from the counter-shaft to the dynamo axle, putting the pulley on both ends so as to insure running at all times. They also have a very ingenious method of keeping the belt stretched by screws at both ends, both operated by one handle by means of a worm gear which pushes the counter-shaft into a position diagonally to or triangularly from, the dynamo axle and from the first main axle of the car, so that it tightens up both series of belts, at the same time. It seems to me there is something which is more theoretically perfect in such a system, which carrying the original power along with it, may also carry and excite batteries, to maintain the light when the dynamo is at rest, than there is in any other system. Of course, the objection that is stated against that in this country is very weighty; but I think the time will come when our cars, as well as our houses, our stores, and our business blocks, will be properly fitted for the use of every electrical appliance, with, I hope, one exception. While we want all the light we can get while we are travelling (except in tunnels,) we do not want, at least I do not want, ever to be telephoned to, or to telephone a message, or to be telegraphed to, or to send a telegraphic message to anybody while I am on the train. I think, all who have to work as hard as you do, will agree with me on that point. The steamship or the train is now our sole refuge. (Laughter and applause.) We want at least one haven of rest where the wicked will cease from troubling. One gentleman questions in some degree, whether using the power of the locomotive to operate the shafts of the dynamo would not detract somewhat from the tractive power of the locomotive. Mr. Blodgett answered it very well, as I thought; but that question appears to have already settled itself, when we consider the English method of getting light on a train. I read very carefully the paper written by one of the inventors of that system before the Institute of Civil Engineers in London on that point, and, while it may be that he is wilfully disguising the truth, he being an inventor, yet it is a fact that he says nothing about any such loss of power, if it occurs. He does not seem to intimate that the locomotive goes any slower between London and Brighton, or that it uses any more coal, or that it uses any more steam. It may be that it does. At all events the locomotive does not appear to feel the extra strain upon it at all. It gets there just the same. Without any disposition to criticise, I notice one statement of Mr. Blodgett that was very interesting, yet I do not know that it completely covers the ground. He remarked, when discussing the difference of cost, which seemed to be considerably in favor of oil over electricity, that the amount of light which we used to have under the old oil administration, before Mr. Cleveland was elected, (Laughter) was not half as much as we get now. Well, we all know that is true. We did not get one-half or one-tenth as much light as we get now. It was worth one good pair of eyes to try to read for ten miles. But in view of the fact that when we get a certain amount of light from a certain amount of electrical power, it takes a very little more electrical power to bring the light up to a much higher degree of brilliancy, it is a question with me whether, if we brought the light down to the old standard, the cost would be very much diminished. I rather doubt it.

Mr. Blodgett:—It may be, Mr. President, that I did not make that part of my statement sufficiently clear. I meant to be understood as saying that, if we put in lamps enough in a car only to light the car to the same degree of brilliancy that was obtained by oil, then the cost would be no more than that of oil; not by using the same number of lamps we are at present using, but by putting in a less number. It is true that, if you decrease the candle-power of the lamps, you use a larger proportion of energy to produce that candle-power—a larger proportion per candle-power than if they are running at a higher candle-power. But using a less number of lamps and lighting the car the same as it was lighted with oil, the cost, I think, would be no greater than with oil. We ought to consider that, in a lamp of say sixteen candle-power, perhaps one-half of the light and perhaps a larger portion is cut off from available use by the fixture of the lamp itself. In the electric lamp there is no fixture to cast a shadow or absorb the light, and withdraw it from a useful purpose.

MR. LOCKWOOD:—I am very glad to get that explanation. The last paragraph of this most interesting paper reads as follows:

> Oil lamps, and stoves in cars, must follow where the old couplers and hand brakes for passenger trains have gone in this country, until electricity and steam heat have made the roasting alive of scores of people pinned fast in a railroad wreck as impossible as the air brake and Miller platform have made the telescoping of a train into a shapeless mass of ruins, as happened formerly so often. Not many years hence, we may well hope, one will be as uncommon as the other.

A great English poet once said: "Hope springs eternal in the human breast." And I am quite sure that if we get all the incandescent lamps that we can, and light our train as brilliantly as possible, and leave out the stoves, that the railroad companies will still find some way to get square with us. They will put bridges askew or build tin bridges where iron bridges should be placed.

What I wanted to mention was that there are people to whose perversity I feel that I cannot do justice. I refer to the person who deliberately pulls up his window on a dusty day in front of you, and in that respect I must say our English cousins who are generally behind us are ahead of us. Not only did they start train lighting long before we did, and run it to a greater degree of perfection than we did, but they are using the window which we are now using for street cars. Now if car builders will adopt that sort of window so that we could lower it instead of raising it, it would do away with the blasphemous thoughts which arise in our breasts on many occasions.

MR. WETZLER:—Mr. Ries has led the discussion in a direction which I think would still bear pursuing a little further. He refers to the fact that where storage batteries are used on trains, some account should be taken of a method by which trains running down grade shall be enabled to charge batteries; that these means must to a certain extent be automatic seems self-evident, and I believe Mr. Ries's modesty is such that he has withheld something from us that would shed some light upon the subject. I would, therefore, like to hear his views on this question.

MR. RIES:—In respect to Mr. Wetzler's kind suggestion, I would state that while not fully at liberty to mention what he undoubtedly refers to, I might say that I have given some attention to this matter of accumulating the surplus energy of a train and storing it in the form of electrical energy, and among the problems was the one that Mr. Blodgett suggested in reference to the axle of the car, which I believe we have solved. There is also another objection, and that is, that as the speed of the train slackens, naturally, the electromotive force of the current produced decreases and means must be provided for maintaining that up to the standard, so that the batteries will not discharge through the generator. There are other matters which, of course, suggest themselves in this connection, but we might say in a general way this: Taking the ordinary trunk line road, we find a great many with very steep gradients; the energy of the locomotive used in propelling a train up a steep incline is ordinarily wasted on the next descending grade by the energy of the train being checked and further steam applied to check it by means of the brakes. Now, the energy of a train can as well be checked by attaching a generator to the axle directly or by means of belts, the direct connection being preferable, and forcing that to generate more or less current. In order to accomplish this I have devised a form of pendulum switch—or any other form of gravity switch will answer—whereby the amount of current produced by a generator for charging the battery is directly proportional to the inclination of the grade; so that as long as the train is running on a level the field magnet coils of the generator are open, and the magnetic saturation can be increased or diminished at will. The number of coils thrown into the circuit is automatically adjusted by means of this switch before mentioned, whereby, when the train is running down on a steeper incline than before, it makes a stronger magnetic field, retards a greater proportion of the energy of the train and generates a correspondingly increased volume of current which is stored in a battery for use as required. Now, the greatest expense in the present method of lighting railroad trains by batteries seems to be in the cost of charging. A further expense in some systems arises from the fact of using a double set of batteries, one of which is being charged while the other is being worked—both of which can be dispensed with—as well as the cost of handling. By means of a system of this kind the battery when once in position is self-charging, so to speak. A sufficent number of cells are used to give you the requisite number of ampere hours, and the number of cells that we do use, of course, will be determined by the number of hours that your train is running. The generator is so arranged that, as before stated, in running on a small incline, the field magnet strength is slightly decreased, but as the speed of the train slackens, in case of wanting to come to a stop, the field magnet strength is automatically increased. We have both a gravity switch and governor in this arrangement, so that the electromotive force is produced until the speed of the train has very nearly ceased. In that way the battery will always have a sufficient supply of current in reserve, whether it be used for lighting or braking or whatever other applications you may wish to employ. The system, of course, is as yet somewhat incomplete, but is being developed, and I hope at some future time to go more into detail in regard to it.

Mr. Mailloux:—As those who have preceded me remarked, we have in this branch of the discussion a most interesting and perhaps timely topic, and I can state here, semi-officially that the Julien company is, and has been for some time actively engaged in the study of that very question. I have had several communications upon the subject from Mr. Julien, who is now abroad, besides having given a great deal of attention to the matter myself.

I must say that I do not quite agree with Mr. Ries, in his views on the subject of utilizing only wasted energy. This idea of using waste energy is very good in theory, but it does not always work in practice. A car starts from here to go to St. Louis, or some distant point, a trip requiring a considerable length of time. Now, what a practical lighting man, like Mr. Blodgett, wants to know is, how many hours of artificial light will be required; how many lighting hours of electricity he has got to supply that want, and with him it is of far more importance to be able to get at so many ampere hours per mile, than it is to take his chances of getting it at the next grade, or giving the engine a spurt so as to get it on going down a grade. Therefore, I believe that as the amount of energy which is constantly being drawn upon, in a car making a long trip is so small, that it will be better in practice to content ourselves in drawing it directly, without paying attention to what is being saved or to what might be saved. In a car travelling all day, it is safe to say that excluding the time of stoppages, we have something like twenty or twenty-two hours of travel. Now, if we so arrange the apparatus that we can draw a small current for those twenty-two hours, it is quite evident that the draft might be large, and as Mr. Lockwood, very aptly remarked, doubtless the strain on the constitution of the iron horse might be very appreciable. On the other hand the hours of lighting will never be so long, because in sleeping cars after certain hours there are very few lights in use. The policy which the Julien company has pursued has been to aim at simplicity and to so arrange apparatus that it can be put into the hands of whomsoever may be called upon to direct its application, and with that in view we have sought to eliminate as far as possible, all elements of complication in the way of regulating gear. Not long ago, I visited a train of which Mr. Blodgett spoke in his paper, in which the attempt is made to get motive power from the axle. I found, on arriving there, that the gentleman had almost converted the baggage car into a machine shop. He had very complicated machinery below, and upon entering the car I found that he had very complicated machinery inside. He informed me that the system worked very nicely indeed. I did not wonder. It ought to work beautifully with the amount of complication that he succeeded in introducing into it. But I doubt very much whether the average railroad manager, or superintendent, or master mechanic, or whoever the official is that is charged with the lighting of cars, would be satisfied to accept the introduction of such a system on his road. It seems also that on roads having considerable traffic it would be necessary for them to provide an additional baggage car, because there is no space left in the compartment in which the machinery is put, and it would be cheaper to go the whole extent, put in power, make the car a little smaller, and call it a lighting car.

The system at which, it seems to me, we should aim, is a system in which there is little or no complication. As you all know, the fact must be borne in mind, that a train will run anywhere from ten to fifty miles an hour. Now, in order to compass the great variations, consequent on such a change of speed, the minds of electricians have been filled with numerous devices of resistance regulators, etc. Now, I do not see that any system involving the application of complicated regulating devices of that kind can hope to be successful. We must have a system in which the mechanism is so simple that there are practically no details to it. If we can have a dynamo that will take care of itself, we are working in the right direction. I remember that at a previous meeting, during a discussion on electric street cars, Mr. Field remarked on the sparking of the dynamo, that he proposed to let the sparking take care of itself. Now, I think that is the key-note of what we should do in the lighting of cars. Undoubtedly the day of lighting cars with an axle dynamo is coming, and when it has come, we shall find that the proper system is that in which the dynamo is taking care of itself, without having to call upon a thousand and one details of machinery and clock-work to assist in taking care of its work.

MR. RIES:—Mr. Mailloux made a very forcible argument in support of the direct dynamo connection for generating purposes. I fully agree with him, that that would be the simplest as well as the best system to adopt in practice on such roads where for certain reasons the momentum system suggested before would not be applicable. But it is a well known fact that a great deal of power is lost every day on our trunk line roads, from the very cause mentioned, and the secondary battery presents to us a useful and simple means of converting at least a portion of that energy into use. Now, I do not advocate this system on level or substantially level roads. It is only in cases where the advantages would justify its adoption that I would recommend it. For ordinary roads, however, the direct dynamo and battery connection as recommended by Mr. Mailloux, is perfectly proper and probably the best plan to adopt.

MR. PENDLETON:—While listening to the remarks on the accumulator and the care with which it has been attempted to work out a system, simple and effective, for the purpose of lighting railway cars, I failed to see where there is, in the necessities of the application, room for very great study. The principle of the accumulator is that one ounce of material will hold a certain quantity of chemical energy. That was the feature of the Faure battery of 1880, and as nature is generally regular in her habits, we may calculate that one ounce in 1880, of peroxide of lead would hold as much nearly, as it will at the present time. There have been certain improvements made, however, in the accumulator, of decreased resistance, and capacity increased relatively to the weight of the battery; so that at the present time there is improvement, but the basic element remains the same. The feature in the storage battery appears to me to be one of inherent character which is difficult to overcome, except by the intelligent application which Mr. Blodgett has to-night mentioned of switching in additional cells. We all know the effect if the electromotive force of the battery fails to be discharged. There is another and unfortunate effect, in that the resistance of the lamp is also increasing; requiring some means of keeping up the electromotive force and keeping down the resistance of the incandescent lamp. Some years ago that feature troubled me considerably, as to the application of storage battery plants for general use, and I felt that the storage battery when applied would find its great use in power, in the application to street cars, in the application to motors, etc., and which is now being developed to an extent which makes the subject very interesting. We have seen in our streets a car, the mechanical construction of which being completed in a foreign country was not exactly suited to our railways. I do not know whether it has yet been brought to a point of perfection. But at any rate, competent electricians riding on the car stated that the defects were purely mechanical and that the electrical performance of the car ought to satisfy anyone informed upon the subject of electrical work and the action of the motor. A number of cars are being built, and what was a dream among electricians, six or twelve months ago, will very shortly be in practical use. Railroad men generally are very slow to take hold of improvements in their different systems. So many unfortunate experiments make them weary, and it is only after most thorough and careful tests that they are disposed to adopt new devices.

In the matter of lighting cars by electricity, I think Mr. Mailloux is at fault in stating that it has not before been accomplished in this country. I recollect the Pennsylvania Railway Company making experiments in 1883. I paid but little attention to them. I know also that in England in 1882 the London and Brighton train was lighted by accumulators, and so continued for several years and may, for all I know, be so lighted at the present time. There is nothing new in the matter. The fact has been demonstrated that the Julien battery is a well manufactured, good accumulator for the purpose—as good as any that is made. The claims for efficiency are high. I hardly believe that it is intended that 85% as claimed is the efficiency of the battery. I know of recent tests made where the efficiency, the return of power, was determined to be 65 per cent. and was considered very satisfactory. I certainly found it so, because it proved a belief that I had that the true efficiency of an accumulator was 50 per cent. I recollect at a former meeting of this society when I stated that fact, it was doubted. With 65 or 66 per cent. return from the battery, and allowing 15 per cent. loss in the motor; this 50 per cent. efficiency is realized in the use of the storage battery for propulsion purposes, and as the tests were made under the supervision of your late president, Mr. Pope, I know that they are thoroughly reliable. It is a return that must bring the battery for the purpose of propelling cars into very general use, and I know already of several cars being built for the purpose of testing the matter.

Mr. Mailloux:—I would like to make a few remarks which it would be well to place on the record in this connection, as Mr. Pendleton, my friend and esteemed colleague, has made some remarks which refer to the Julien battery of which I am one of the representatives here. With due respect to Mr. Pendleton, I must say that he likes to live in the past. He has been pleased to go back to the time of Faure and tell us that an ounce of active matter was capable of storing a certain amount of energy. I would like to take him back further, to the time of Plantè, and show him that an ounce of matter also had the power to store a certain amount of energy, and I may even go further back than that. An ounce of matter in a storage battery—peroxide—is capable of holding a certain amount of energy. Now, with regard to the efficiency, I would like to call the gentleman's attention to the fact that efficiency in train lighting is quite a different thing from efficiency in the case of motor traction; and as I told him at the meeting where we had the discussion on electric motors, it is quite important to take into consideration the successive transformations that the energy has to undergo. It is necessary that we should know where the final absorption of the energy takes place. If we are going to take the energy and transform it several times, each time we have to take into account a coefficient of loss which he fails to take into consideration. I think we can easily show that the efficiency of electrical energy in lighting is much higher than 65 per cent. It is true that there is nothing new with regard to the application of electricity to train lighting, using storage batteries or any other means. At the same time anybody who has studied the question realizes that there are many different conditions to meet, and that because it is not new, does not prove that it is undeserving of our attention. There are in it some problems which call for the highest knowledge of the electrician, and the highest skill of the engineer, and I think it is well to bear those subjects in mind.

The President:—I think we have spent a very pleasant and profitable evening, and we are greatly indebted to Mr. Blodgett for the admirable paper he presented to us, and which has brought out so valuable a discussion.

There being no further discussion of the subject, I declare the meeting adjourned.

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of the

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of

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Annual Meeting, May 17th,

And Special Meeting, June 28th, 1887.

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May 17th, 1887.

The Annual Meeting was called to order at the house of the American Society of Civil Engineers, 127 East 23d Street, New York, at 8.45 P. M., by the President of the Institute, Mr. Frank L. Pope.

The President:—We have met this evening to hold the fourth annual meeting of the American Institute of Electrical Engineers, for the election of officers for the ensuing year and the transaction of any other business that may come before the meeting. The first thing on the order of business is the reading of the reports. The Secretary, I think, has his report ready.

Captain O. E. Michaelis:—Might it not perhaps save time if a motion were now made to appoint a committee to select names to present for the vacant offices, so that they might retire and make up their list and present it when the time comes?

The President:—I will accept that as a motion if any member will second it.

The motion was seconded and carried.

The President:—I will appoint on that Committee, Captain O. E. Michaelis, Mr. Geo. M. Phelps, Jr., and Mr. Joseph Wetzler.

The Secretary:—Mr. President, before the Committee withdraws I will read a list of the retiring officers for their information. The retiring officers, according to the by-laws, are, F. L. Pope, President; F. W. Jones and D. H. Bates, Vice-presidents, who retire according to the by-laws by the expiration of their terms of office; Mr. T. D. Lockwood, elected vice-president last year has resigned. The resignation was held over by the Council, but the gentleman insists upon resigning, because he is so situated that he cannot perform the active duties of the office, and he claims that his platform is, that an officer should be an active agent, and he cannot be consistent in that position unless he retires himself. Professor W. A. Anthony, elected to fill a short term in place of F. L. Pope, who was elected President last year, That makes four vice-presidents to be elected. The retiring managers are, C. F. Brush, Prof. E. J. Houston, T. C. Martin and Edward Weston. The other officers, whose terms expire, are, Treasurer R. R. Hazard; Secretary R. W. Pope.

THE SECRETARY then read his report as follows:

SECRETARY'S REPORT.

To the President and Members of the American Institute of Electrical Engineers.

As the Institute is about entering upon its fourth year, it appears to be an appropriate time to review its record, examine the field of its operations, and prepare for extending its usefulness in the future. The reasons for its existence are more apparent than they were three years ago. While all of us realized at that time, that electrical industries were in their infancy, the importance of scientific training was not appreciated as it should have been. It is now generally admitted that the best commercial results can be obtained in the electrical field by following out scientific theories, especially where they have been confirmed by practice.

If we have learned all there is to be extracted from the study and practice of electricity, the Institute has no mission. If, however, we are progressive, and desire to obtain further knowlege of the art as we perform our various duties in this growing field, then we should not only continue the good work we have undertaken but seek to extend the usefulness of the Institute by bringing to its support all who are in any manner interested in the various applications of electricity, and are desirous not only of profiting by the experience of others, but are willing to contribute their own ideas for the benefit of their fellow members.

As stated in my last annual report, there were upon the roll of the Institute a large proportion of names which had been placed there at the time of organization without proper authority. By instruction of the Council, circulars were forwarded to all of these requesting that they express their views as to accepting associate membership. Acting upon further instruction of the Council, the names of those who responded unfavorably, or who failed to reply to the request were stricken from the roll. Although this resulted in a loss of seventy names, it was apparent, rather than real, as the Institute had never received active support from them.

There still remains upon the roll, however, the usual percentage of delinquents, most of whom joined during the enthusiasm of organization, and, who having since lost interest in the welfare of the Institute, are practically of no benefit to it. The Institute having now apparently passed the critical period in its existence and attained a recognized scientific standing at home and abroad, far in advance of all other strictly electrical associations in the country, membership in it is correspondingly appreciated.

It is the only association, national in its character, which brings into the arena of discussion all branches of electrical research, and it may be added that in none of them are such subjects so thoroughly and intelligently treated, and so accurately recorded, and published for the information of absent members, as well as for future reference. To build up such an organization; to secure the active support of patient, zealous workers, until it attains full recognition, as a worthy public institution is a difficult undertaking; and that we have reached our third anniversary with bright prospects for the future is a very encouraging fact.

Two previous reports have directed your attention to the importance of holding more frequent meetings, in order to awaken and maintain interest in the welfare of the Institute, which it was feared might lose ground, unless opportunities were offered for occasional gatherings during the year. Acting upon these suggestions, four meetings have been held since the 18th of May, 1886. The proceedings of these meetings were very fully reported in the electrical journals, and were also copied in foreign electrical periodicals. They have been beneficial to the Institute in various ways, and it is to be hoped that our members will contribute during the coming year a sufficient number of papers to enable us to hold at least eight similar meetings.

Nothing whatever has been accomplished toward securing permanent quarters, and this is perhaps the most serious obstacle which remains to be overcome. The continued courtesy of the American Society of Civil Engineers in granting us the use of their rooms for our Council and general meetings, while most heartily appreciated, does not satisfy the natural desire for a home of our own, and until this end is attained, it is hardly possible that the full benefit of organization can be realized. The receipts of the year were $1,082.80, being $107.55 in excess of the previous year, while the expenses have been about $200 less, leaving an apparent balance in the treasury of about $400, after all obligations are paid. As our receipts are now greater than our expenses, this surplus ought not to be reduced. The present condition of our affairs is such that I believe a much better showing may be made during the coming year, and I see no reason why we should not move forward with confidence toward attaining that most desirable achievement in the history of any similar society—a permanent record of scientific papers and discussions of which every member should be proud, based as it is upon the intelligent researches of its supporters.

Respectfully submitted,

RALPH W. POPE,
Secretary.

NEW YORK, May 17th, 1887.

RECEIPTS DURING THE YEAR IN DETAIL.

[Entrance Fees in Brackets.]

MAY, 1886.		
17	L. C. Baker	$10.00
17	Moses G. Farmer	10.00
19	E. P. Roberts	10.00
19	J. S. Ross	10.00
20	Geo. C. Maynard	10.00
20	Wm. Wallace	10.00
JUNE.		
8	W. M. Callender	10.00
9	P. B. Delany	10.00
9	M. M. Davis	10.00
16	G. A. Hamilton	10.00
16	W. J. Johnston	10.00
16	D. H. Bates	10.00
16	E. J. Houston	10.00
16	Leo Daft	10.00
17	S. M. Plush	10.00
17	E. H. Goff	20.00
17	C. B. Whiting	10.00
18	H. L. Roosevelt	10.00
18	Chas. R. Cross	10.00
19	T. C. Martin	10.00
19	C. J. Glidden	10.00
19	W. H. Forbes	10.00
21	J. F. Morrison	10.00
21	S. D. Field	20.00
21	J. A. Miller	10.00
21	W. A. Anthony	10.00
22	E. N. Dickerson, Jr.	10.00
24	M. G. Farmer	10.00
24	R. K. Dana	10.00
24	C. F. Brackett	10.00
24	T. D. Lockwood	10.00
24	E. H. Brooks	10.00
29	G. F. Durant	10.00
29	F. W. Jones	10.00
29	J. M. Mitchell	10.00
29	J. P. Davis	10.00
29	F. P. Mills	10.00
30	G. W. Stockly	10.00

JULY.		
1	C. F. Brush	$20.00
9	C. C. Hall	10.00
12	E. P. Thompson	10.00
13	F. L. Pope [$5.00]	35.00
17	W. B. Vansize	10.00
17	H. C. Adams	10.00
17	E. G. Bernard	10.00
19	E. Weston	10.00
20	F. A. Mason	10.00
20	W. D. Sargent	10.00
20	C. L. Bruns	10.00
23	E. F. Phillips [$5.]	14.16
27	J. E. Smith	20.00
28	C. W. Raymond [$5]	15.00
AUG.		
5	R. S. Waring	10.00
13	G. W. Mansfield	10.00
13	G. M. Phelps, Jr.	10.00
13	Jesse M. Smith	10.00
SEP.		
4	C. Williams, Jr.	10.00
16	S. F. Shelbourne	10.00
28	C. E. Chinnock	10.00
OCT.		
1	C. F. Chandler	10.00
14	Ph. Diehl	10.00
18	H. I. Iselin	10.00
NOV.		
24	F. Van Vleck [$5.]	10.56
DEC.		
6	M. B. Leonard [$5]	10.56
7	S. S. Wheeler	10.00
13	A. R. Ledoux. [$5]	10.00
13	Sam'l Insull	10.00
JAN., 1887.		
1	R. W. Pope [$5.]	25.00
MAR.		
9	H. C. White	10.00
10	C. L. Clarke	10.00
11	W. P. Trowbridge	10.00

MAR.		
14	C. A. Doremus...	10.00
14	Wm. Wallace	10.00
14	H. C. Roome... .	10.00
14	W. B. Cleveland..	10.00
15	Adam Bosch.....	10.00
18	R. Hewitt, Jr.....	10.00
18	T. A. Edison.....	10.00
19	Theo. N. Vail....	10.00
24	Dr. Norvin Green.	10.00
25	L. C. Baker......	10.00
28	C. O. Mailloux....	10.00
APRIL.		
1	C. A. Cheever....	20.00
2	O. E. Michaelis...	10.00
6	C. B. Hotchkiss [$5]	6.67
14	C. A. Terry.. [$5.]	6.67
	Alex Graham Bell.	10.00
	Hartley Gisborne..	10.85
16	T. H. Delano.....	10.00
19	Henry Metzger...	10.00
22	A. C. Fowler [$5.]	13.33
22	W. S. Turner.....	10.00
24	E. P. Roberts.....	10.00
29	Jos. Wetzler......	10.00
29	F. W. Royce.....	10.00
MAY.		
11	J. P. Abernethy..	10.00
12	T. C. Martin.....	10.00
13	D. C. Jackson [$5.]	15.00
	Total.........	$1,082.80

SECRETARY'S BALANCE SHEET.

May 16, 1887.

R. W. POPE, SECRETARY, IN ACCOUNT WITH THE A. I. of E. E.

Dr.		*Cr.*	
1887.		1887.	
Balance from 1886.....	$ .91	Cash to Treasurer	$863.97
Dues from Members, as per list, including $55 Entrance Fees.	1,082.80	Messenger	.32
		Postage	33.63
		Dinners, guests and deficiencies	5.00
		Stationery...	4,10
		Blackboard..	3,00
		Cartage........,..........	.75
		Stenographer, (2 meetings).	20.00
		Copyright	1.02
		Balance on hand	151.92
	$1,083.71		$1,083.71

E. & O. E.

NOTE.—Other expenses of the year having been paid by the Treasurer, do not appear in the above statement.

Mr. T. C. Martin:—I move that the list of members who have paid their dues which is appended to the Secretary's report be taken as read.

The motion was carried.

Mr. Martin:—I have a list of members in my hand. I think it would be well before we proceed to the election of officers to have the names of all the members in good standing read.

The President:—If you will wait a moment, Mr. Martin, we will see what action is taken on the Secretary's report.

Captain Michaelis:—I move that the report be accepted and printed in the transactions.

The motion is carried.

The President:—The Treasurer has failed to file any report in time for action by the meeting and we shall have to depend for knowledge of the state of our finances on information that the Secretary has kindly collected for us.

The Secretary then read the list of members.

The Secretary:—I might say, in regard to this list, that I wished to avail myself of the opportunity to send it out with the invitations to the collation this afternoon, and in order to do that, I had no time to compare it with the records and check it off, and I find that I omitted one or two names—the name of E. P. Thompson, and that of William Lee Church, a recent member, and we have added to-night the following new associate members: W. Dwight Wiman, Francis R. Upton, C. L. Edgar, Clarence E. Stump, J. O. Ellinger, Alexander P. Wright, Otto A. Moses, Lieut. E. Zalinski, United States Army, I. L. Roberts, and Lieut. W. D. Weaver, United States Navy—ten in all.

The President:—The list of members shows a healthy and continuous growth. I think we may congratulate ourselves on the interest that is being taken by the electricians of the country in the prosperity of the Institute, which is evinced in the best possible manner by sending their names in as candidates for membership, and we may congratulate ourselves also on the quality of the new accessions as well as upon their number. We are now ready, I believe, to proceed to the election of officers, and Captain Michaelis will read the nominations.

Captain Michaelis:—The committee appointed to make nominations have availed themselves of information received from members. There has been considerable discussion of the subject of filling vacancies during the past month—ever since the last Council meeting, and their prompt action is due to the fact that they were well informed in regard to the wishes of the members, and in suggesting names they have not strictly followed the idea which is the basis of our constitution with regard to geographical distribution, but they felt that during the early years of the society, it would be well to have in the Council, men who would attend its meetings and be active in forwarding the interests of the Institute. In regard to one nomination, in which the feeling was unanimous, they are sorry to have to report that they could not meet the unanimous wishes of the members they have come in contact with during the past month, and that is in regard to the office of President. It has undoubtedly been the wish of every member of this society, that our present distinguished President, would be willing to accept another term; but he has positively declined, nothwithstanding all influences that were brought to bear upon him. He will not accept the office again and his reasons are, namely: what he considers the best interest of the society. In the first place, he desires to establish the precedent that there should be rotation in office and that one term is sufficient, but I am glad to say that he has consented to permit his name to be used as a candidate for vice-president. The committee has therefore nominated for the office of President, a gentleman than whom there is no other one, who has shown more interest in our progress, or who has done more for us; we nominate for the office of President, Mr. T. C. Martin; for Vice-presidents, to fill the full term of two years, Mr. F. L. Pope, Col. R. R. Hazard and Prof. W. A. Anthony, and to fill the vacancy for one year, made by the resignation of Mr. Lockwood, Prof. Elihu Thomson; for Secretary it is needless to state the committee's nominee—our present incumbent, whose able report we have just listened to with great pleasure, Mr. R. W. Pope; for Treasurer, the committee has transferred one of the Managers of the Institute, as the present Treasurer has been promoted to be Vice-president; we nominate (two of the committee do at least,) to that office, Mr. George M. Phelps, Jr.; for Managers, Messrs. Schuyler S. Wheeler, Joseph Wetzler, A. C. Fowler and William Lee Church, and for the unexpired term created by the transfer of Mr. Phelps to the treasurership, Mr. Edward P. Thompson.

THE PRESIDENT:—You have heard the nominations brought in by the committee. Any further nominations are now in order.

A Member:—I move that the nominations be closed.

The motion was carried.

The President:—We are now ready to proceed to the election.

Mr. Phelps:—I do not know whether it is necessary to make a motion, but if it is, I would move that two tellers or scrutineers be appointed.

Captain Michaelis:—The Constitution provides for that.

Mr. Wetzler:—I think as there is only one set of nominations the matter might be expedited by requesting the Secretary to cast the vote of the Institute. I make the motion that the Secretary cast the vote of the Institute.

Mr. Mailloux:—I second the motion.

The Secretary:—It requires unanimous consent to do that.

Mr. Phelps:—Would not the proper procedure be for the Secretary to cast a separate vote for each name? Would it be proper to lump the whole Council and everything together?

The Secretary:—It appears to me it is a matter of precedent. So far as I am concerned, I would like to see the ballots taken separately for the vice-presidents in a lump, and the managers in a lump, or else for each one individually. If there is no objection made, we can go on and elect them all in a lump by ballot, I suppose.

Mr. Wheeler:—It seems to me as if that might bring up some question about the legality of the election, but to expedite that, how would it do to pass the sheet around and have each one of us declare that it is his ballot?

Captain Michaelis:—I find that the committee on nominations has made a mistake in regard to two officers. The Constitution declares that vacancies shall be filled by the Council, so that the committee will have to withdraw the nomination of Prof. Thomson for Vice-President, and for Manager, Mr. Edward P. Thompson.

The President:—That can be done without any action on the part of the meeting.

Captain Michaelis:—I second Mr. Wetzler's motion, Mr. President, that the Secretary cast the ballot for the members. Did I understand Mr. Wetzler that he wished to cast his ballot for the whole ticket?

Mr. Wetzler:—Yes, sir.

The motion was carried.

The President:—There can be no question as to the legality of it, if no one objects.

The Secretary:—Do I understand now that the meeting is not competent to fill these vacancies and that the nominations to fill them shall be stricken out?

The President:—Yes, and that they should be withdrawn and filled by the Council. I will appoint as tellers to receive this ballot, Mr. Wheeler and Mr. Shelbourne.

The Secretary deposited the ballot with Mr. Shelbourne, as teller, who thereupon announced the names of the persons elected.

The President:—Gentlemen, you have heard the names of candidates selected, as announced, and I hereby declare them elected.

We are now ready, I suppose, for any other business.

Mr. Mailloux:—I think it would be well that the names of the officers still holding office should appear in the list. If it is necessary, I would like to make a motion to that effect, that when the names of the officers are published, that the full list be included, so that members and others, and the public, shall know the entire list of officers of the Institute.

The President:—I think the motion is hardly necessary, Mr. Mailloux, I will instruct the Secretary to have that done.

The Secretary:—Would it not be well to have it understood that we will hold a meeting of the Council after the adjournment of this meeting to fill those vacancies and have the whole business completed?

Mr. Phelps:—I have a resolution to offer. We have all read in the able report of the Secretary the remarks which he has made in respect to our want of habitation, and the fact that we are still indebted to the kindness, but at the same time charity, of others, for a roof over our heads when we get together. It is not disagreeable to come to the house of the civil engineers—it is always a pleasure; but at the same time we would all be happier and the society would be more useful, if we had our own roof; and the desire for that is very general, and some of us are of the opinion that we are better able to accomplish something in that line than we have thought we were. If we would really put our hands to it and undertake it seriously, and with the view of having it done at once, I would offer a resolution, in the hope that it will bring out an expression of opinion and a favorable vote:

Resolved, That in view of the general interest evinced for three years past by members in proposals for some permanent quarters for the Institute, that a committee be appointed at this meeting *to report at the meeting to-morrow on the best plan to be adopted and the sum necessary for the purpose named.*

The resolution was seconded.

MR. SHELBOURNE:—I should like to say that, as I understand it a committee has been appointed and now exists, as just suggested to me, and as my memory serves, for that very purpose—a committee on permanent quarters. I think that committee was appointed more than a year ago, if not two years ago.

MR. MARTIN:—Three years ago.

MR. SHELBOURNE:—Yes; and I should like to know what that committee has been doing all this time, and who composed it.

MR. MARTIN:—I was present at the last meeting of the Council, Mr. President, and the committee in question had no report to make, and as I understand it, this is not any usurpation of the functions of that committee. It is appointing a new committee to start in afresh and to make a record, which the other did not do. I am not aware that the other committee has any *status.*

CAPTAIN MICHAELIS:—Discharge the other committee.

MR. MARTIN:—It expires, sir.

MR. SHELBOURNE:—The point is quite pertinent, but in general I understand that that committee holds on from this day forth.

MR. PHELPS:—In point of fact that question has been out of the hands of the committee more than a year.

CAPTAIN MICHAELIS:—Put in the word "new;" that will settle it.

THE PRESIDENT:—With your permission, Mr. Phelps, I will make the change.

MR. SHELBOURNE:—I do not like to see things duplicated. It is proper that when a committee is appointed for any purpose, before any other committee is appointed for the same purpose that that committee should make a report, or decline, or become *functus officio* in some way. If the committee has not made a report, or has not declared what it was going to do, or considers itself as having reported or discharged, or defunct, why then of course, Mr. Martin's motion would be proper, but only upon that statement.

MR. MARTIN:—That committee, if I am not mistaken, Mr. President, was a committee of the Council, not of this body, and the Council, as master of that proceeding, requires no further service from that committee. We are now asking for the appointment by the chair of a committee out of this body.

MR. SHELBOURNE:—Then my remarks fall.

THE PRESIDENT:—I think Mr. Martin is right, that it was a committee of the Council, and as it does not seem to have accomplished very much, there certainly can be no harm in a committee of the whole Institute trying to see what it can do.

MR. MARTIN:—I would like then to withdraw, if in order, that word "new." It is not a new committee of the Institute at large; it is a committee.

MR. PHELPS:—I think under that ruling, which seems to be quite right, if the old committee was a committee of the Council the resolution had better stand as it did in the first place.

MR. WETZLER:—I think we could separate that matter by making a motion to the effect that the old committee be discharged.

MR. MARTIN:—The record shows that it was a committee of the Council.

THE SECRETARY:—I might add that they have made sundry reports to the Council of different ideas of new buildings put up that we might occupy but there has been nothing definite done.

The resolution was adopted.

THE PRESIDENT:—I will appoint on that committee Mr. Phelps, Mr. Martin and Mr. Hamilton.

THE SECRETARY:—In conversation with Captain Michaelis this evening, it appeared to me that he has some ideas about this question of permanent quarters, which would be of value and he has had a good deal of experience in that direction, and while I do not know if it would be in order to add him to the committee, yet I should like the committee to receive the benefit of his experience in the matter.

THE PRESIDENT:—There is no number specified, and I will therefore add Captain Michaelis to the committee.

THE SECRETARY:—In view of the appointment of this committee on quarters, and also of the fact that the question has come up among sundry members of the Institute in regard to amalgamation, and the bringing in members of another class, and also providing for certain other points that are not covered by the rules, I think it would be well to appoint a committee for the revision of the by-laws to take into consideration those new points, and acting on our experience try to cover them as fully as possible. I believe it would be for the interests of the Institute if we could get a working committee by which something could be accomplished in the direction of extending the influence of the Institute.

MR. MAILLOUX:—I second that motion.

The Secretary:—I made no motion.

The President:—That seems to be an excellent suggestion.

Mr. Martin:—Might we not have that formulated in some way?

The President:—You might put it in the form of a resolution. The suggestion has been made by some of the members—I do not recollect whom—quite recently, that it might be well to establish a junior membership of the younger men who are entering the profession and who are enterprising and industrious workers, but who can hardly afford to pay the regular annual dues of the Institute, and that that membership should have certain restrictions imposed upon it. They should not be above a certain age, perhaps, and possibly there might be some other restrictions of a similar character; and I would suggest, if such a committee is appointed, it might be well to take that matter into consideration. It seems to me that we can in that way get quite a large membership of young men whose fellowship will be of some advantage to us, and a great deal of advantage to them, and it will certainly bring them all into full membership ultimately—every one of them that is worth having.

The Secretary:—There was one other point I wished to cover, providing for monthly meetings. There appears to be no provision in the rules at present for regularly called meetings. They must be special meetings, and the general meetings are not provided for at any special date. It has also come to my notice that there is a field for the establishment of branches of the Institute in some of the large cities of the country, and if we succeed in making the home Institute what it should be, a great deal of good work may be accomplished throughout the country. The electrical interests in other cities are very large, and with a little assistance and advice perhaps, and by providing in the rules for the establishment of such branches, I think that some good may be accomplished in that direction, and I would offer the following resolution:

Resolved, That a committee of five be appointed by the Chair for the purpose of revising the rules to provide for extending the usefulness of the Institute.

That is all there is to it, but, of course, any members having any points to suggest, they can hand them in to the committee.

Mr. Phelps:—To report when?

The Secretary:—At the next meeting.

Mr. Phelps:—To-morrow?

THE SECRETARY:—They could hardly revise the by-laws, but they might make a report covering the points that the rules should provide for.

MR. MAILLOUX:—I think that the whole question is one which might properly be left to the care of the Council. I do not see why the Council should not be authorized to look after this matter, and appoint a committee of its own members to do the work. The Council meets oftener and has better opportunities to canvass these questions and to determine what should be done. Consequently it seems to me that it is a matter coming within its special province, and if Mr. Phelps has no objection it might be put in that form by a motion.

THE PRESIDENT:—The Chair would suggest that it might be perhaps a proper way to get at it, for the meeting to authorize the Council to go on with this work at their discretion. I do not think that there is anything in the constitution or by-laws to prohibit that being done.

CAPTAIN MICHAELIS:—The constitution provides that the rules may be amended at any time by a two-thirds vote, provided a notice be given at the previous meeting, so that the object of having such a resolution as is offered by the Secretary is to give notice; that is all. I presume if this meeting passed a resolution directing the Council to adopt such amendments as they might deem proper, that that would be tantamount to giving them notice; and so it would be in order at any subsequent meeting for the Council to report, and submit the results of their thought and study to the Institute for ballot. I think, Mr. President, this is really a very important subject. We have once amended our constitution and devoted some time to it, and like everything else in the beginning, time shows that we have not done the work, so that it would meet all possible contingencies. We have had an example to-night. There is no provision in the constitution for nominating officers; and there were certain things that occured this evening that were not pleasant to hear. It is perhaps the most important function of a society to nominate proper officers, and that ought to be left to a committee of the society, and that committee ought to be elected by ballot, rather than appointed, so that it will represent the body of the society, rather than any section of it. The other points mentioned by the Secretary, I think are really very important—this junior class and a great many other things, and I cordially support the motion. It really makes very little difference whether the Council be instructed to do it, or whether a committee be appointed by direct vote of the society.

THE PRESIDENT:—I think, perhaps the work could be done as satisfactorily and as quickly by the Council.

MR. WHEELER:—Is there any motion before the house?

THE PRESIDENT:—The resolution by the Secretary.

MR. MAILLOUX:—I should like to offer my remarks just made as an amendment to the resolution offered by Mr. Pope, the Secretary.

MR. PHELPS:—I would suggest that perhaps the simplest and easiest way to get it into shape, upon which I think we are all agreed now, would be simply to put this meeting on record as requesting the Council to take that subject up at an early date, embracing the points expressed in Mr. Pope's resolution, if Mr. Pope would accept that as an addition to his resolution, changing the form of it slightly. I think that would meet the case.

MR. WHEELER:—I suggest this amendment: that the Institute direct the Council to take such steps as they see fit, to increase the membership and the interest in the Institute and make it more popular, and to establish a class of junior membership to enable the Institute to comprehend a great many young men who would be valuable members who cannot be brought in under the regular membership.

MR. PHELPS:—I suppose, Mr. Chairman, that no final action upon any amendment, upon any new programme whatever, any change in our organic law, so to speak, can be made by the Council, even under the instruction of the Institute. The Council will have to report to the Institute.

THE PRESIDENT:—It will have to be sanctioned by the Institute.

MR. WHEELER:—The action is to be taken by the Institute, as I understand, but the thinking has got to be done by the Council. They have got to get out a good programme, and when that is presented to the Institute, it is generally carried through.

CAPTAIN MICHAELIS:—I think that this snarl could be unwound very easily, if the motion was made, that the Council be constituted a committee to take into consideration constitutional amendments, and that the passage of this resolution be deemed the proper constitutional notice; I think it will meet all the points. The Council of its own motion cannot submit amendments under the constitution. You have got to present them at one meeting and act upon them at another, but you cannot constitute the Council a committee and deem this appointment of the Council proper notice of the amendment.

THE PRESIDENT:—It seems to me that meets the case very well.

MR. MARTIN:—Rule 2 provides for three classes of membership, and rule 8 provides that this rule can be amended at any regular meeting by a two-thirds vote of the members present, provided that notice be given, etc. That notice can be given to-night, and the Council should have it in its hands to regulate, classify, and mark the limitations of the new class; and also take in hand those other constitutional amendments.

CAPTAIN MICHAELIS:—It is well enough to try it, but I really think it is impracticable. I think that one of the gentlemen present will agree with me that when you get to amending the constitution the hours slip by.

MR. PHELPS:—If you will pardon me, Mr. President, I do not believe that there is any proper way to avoid one distinct provision—any change in the by-laws or constitution will have to be presented in full at one meeting and acted upon at another. Nothing can substitute that as a notice as far as I can see. The Council might set to work upon the subject, or be requested to go to work, and then report the result of its work at some time, and then at the next meeting after that it could be adopted, but the thing has got to be presented and in shape for consideration during the interval between one meeting and the other.

MR. THOMPSON:—I would make a motion—it may interfere with some other motion—that a committee of three be appointed for the distinct purpose of amending the by-laws. That would be a great deal of work. It needs the constant energy of two or three men who can assemble together and take such time as is needed; so I would make a motion that a committee of three be appointed to amend the by-laws.

THE PRESIDENT:—Mr. Thompson's motion is substantially the same as Mr. Pope's resolution, except that he proposes a committee of three instead of a committee of five. I believe that neither of the motions has yet been seconded.

MR. PHELPS:—If neither motion has been seconded it is open to make another one, and therefore I will simply move that the Council be directed to consider the subject of the revision of the by-laws, or constitution if necessary, with a view of adding a class of junior members and a general view of increasing the scope and usefulness of the society.

The motion was carried.

Captain Michaelis:—I am requested to give notice of the following amendment to our constitution:

The Council shall have power to elect junior associates who shall have been engaged in electrical or cognate industries for one year. These junior associates shall not have the privilege of voting but shall be entitled to be present at meetings, take part in discussions and receive one copy of the proceedings. They shall be required to pay one-half the initiation fee and annual dues.

Mr. Wheeler:—I offer the following amendment to the resolution just read:

That the title of this class be made juniors, and not junior associates, and that the dues be made five dollars a year with copy of the transactions, or three dollars without copy of the transactions, and half of the initiation fee of regular members.

The motion was seconded.

Mr. Phelps:—I suppose this is only a suggestion; we have nothing to vote upon to-night.

The President:—I think you are right, Mr. Phelps.

Captain Michaelis:—I offered this amendment at the request of gentlemen. I think that there is a pressing need for such a resolution or amendment as this is. It is not intended to interfere with the motion heretofore passed in regard to the Council amending the constitution, but it is an important and pressing emergency. The only way we can get at that under the constitution is that when we adjourn to-night the Council shall call a special meeting, which shall have the right to act under the constitution, or that to-morrow be designated as one of the meetings under the constitution, or that fifteen members, or whatever the number is, join now in the call for a special meeting.

Mr. Martin:—There is a meeting to-morrow of which notice has been given.

Captain Michaelis:—Is the meeting to-morrow a business meeting?

The President:—To-morrow is a general meeting, but there is nothing to prevent business being done if you choose to do it.

Captain Michaelis:—The meeting to-morrow is one of the two meetings provided for in the constitution to be called by the Council.

THE PRESIDENT:—Yes, sir. Mr. Wheeler you may incorporate your amendment with Captain Michaelis's.

MR. WHEELER:—It is the same thing, Mr. President.

MR. PHELPS:—I would like to offer a further motion, to wit: That the Council be instructed and authorized to proceed to incorporate the Institute under the laws of the State of New York, appropriate to such a society, and with power to designate from their own number a Board of Trustees.

MR. MARTIN:—I second that motion. It is highly important that that step should be taken.

MR. PHELPS:—It is obvious, that in respect to the resolution that has been offered for a committee to report a scheme for permanent quarters, that should that resolution bear fruit, and should we take up that work in earnest, it is essential that we should be incorporated in order to take possession of any funds or property which we might acquire.

THE PRESIDENT:—There is no question about the necessity of it. You have heard the resolution made and seconded.

CAPTAIN MICHAELIS:—I think something ought to be added to that resolution. There are two laws under which we can be incorporated; the old law of 1848, and the Limited Liability Act. The law of 1848, is very simple; it provides for capital, etc., and the law passed within six months, provides a tax on capital. It is a very simple matter to incorporate the society. All you have to do is to file a certificate with the Secretary of State at Albany. But the question of capital will have to be decided on, also other details. Clubs have been organized and incorporated without capital, and I think it is perfectly feasible to do that and still hold title to real estate, and we would save the tax. But that is a matter I should think for the Institute to decide, whether they want to be a capitalized concern.

THE PRESIDENT:—There is no tax on religious organizations, is there?

CAPTAIN MICHAELIS:—If they have capital, there is. All capital is subject to one-eighth of one per cent.

MR. PHELPS:—The intent of my resolution was that we should incorporate as similar societies do. I supposed that such societies were seldom incorporated with capital. But if it should be necessary we might add to it, although I doubt whether it is. It will be necessary for the committee to look into the question and see that it is incorporated in a proper way.

The President:—I should think it might be well to leave that to the discretion of the Council.

Mr. Shelbourne:—I happen to know that societies for religious, literary and benevolent purposes, and the like, are not taxed upon their capital. They are taxed, however; corporations must pay a tax of one-eighth of one per cent. (that is what Captain Michaelis referred to), upon their proposed capital for the franchise of incorporation. That law is general and was passed as recently as April of last year, and provides for a tax of one-eighth of one per cent. upon the capital. Now, if a society for benevolent purposes can be incorporated upon a nominal capital, or a nominal number of shares, why, the tax would be very light indeed. But there is no tax under the law of 1880 as amended in 1881, 1883, and 1885. That provides for a tax upon the capital stock, franchises and business of certain corporations which are named.

The President:—Does any one know if there is any objection to incorporating under the laws of some other state than under the laws of the state of New York? Our organization is a national one, although our property is here.

Mr. Shelbourne:—The corporation laws of all the states differ in some respects peculiar to their own institutions, and the opinions of their own people, and that is a matter for a lawyer to hunt through the laws of the different states to determine; and lawyers in this state have sometimes passed days, and even weeks on that very question in advising whether it is better to incorporate under the laws of West Virginia, or the laws of Maine, or some other state.

The Secretary:—It appears to me that this question can be very properly left to the Council with power. There are other institutions similar to ours that have been incorporated; and I presume that their experience can be very properly followed by us.

The President:—As the question stands now seconded, it will leave the matter to the Council, and I call for a vote on that proposition.

The motion was carried.

Mr. Wheeler:—I give notice that at the next meeting I will offer the following amendment to the constitution:

"The Council shall have power to elect juniors who have been engaged in electrical or cognate interests for one year or more.

These juniors shall not have the privilege of voting, but shall be entitled to be present at the meetings and take part in the discussions. They shall be required to pay one-half the initiation fee and five dollars annually, with one copy of the transactions, or three dollars annually, without."

The Secretary:—This I suppose is a notice of a proposed amendment to the Rules. It is not exactly in accordance with the rules as they stand; for instance, the present initiation fee is five dollars; half that would be two dollars and a half, and half the annual dues would be five dollars. Is it the intention of the resolution to require them to pay half the initiation fee—two dollars and a half, and half the annual dues—five dollars, including the transactions, and three dollars without the transactions?

Mr. Wheeler:—That is the idea.

The Secretary:—It seems to me that it would be better to take it in hand and make the matter right, so that there will be no misunderstanding about it. It is sufficient for you to give notice that you propose some amendment, and then put it in such shape that it will accord with the rules as they now stand.

Mr. Wheeler:—That can be done to-morrow, can it not? I simply offer that as a notice.

Captain Michaelis:—If we were to get a house it is very evident that the dues would have to be raised. It is impossible to run a club-house in the city of New York, with twenty-five cents a month per member, or even at fifty cents, which would make six dollars a year. At the present rate it would not begin to pay the rent or the interest on the debt, or anything else. The chances are that if we get a club-house and a place to meet, and have it open, the dues of resident members may have to be increased. You cannot have a club-house in the city of New York and charge members less than a dollar a month for its privileges. That is out of the question.

The President:—There are two things to be considered in that matter. It seems to me one is; there is a large number of these young men who, if we do not take in at the reduced price, will not come in at all. And another matter is that I think it would be well to have some limit of age, or some limit of time; otherwise you might have men coming in as juniors and staying as juniors until they were seventy years old.

Mr. Wheeler:—I will suggest that it is not the age that will always determine whether a man is qualified to become a junior or not. It would be better to limit his time as a junior to a certain number of years after he has been admitted as a junior.

The President:—I should think five years would be as much as would be necessary.

Mr. Phelps:—That would be an ample limit, because if a man—young or old—comes in as a junior and can pay three dollars a year, if after working five years longer at electricity he could not then earn enough to pay us our full fee, he cannot be much of a member.

The President:—I think you are right, Mr. Phelps, and perhaps, on second thought, three years would be as long as is advisable.

Mr. Shelbourne:—I have not heard of this proposition before this evening. The feeling with which it strikes me is decidedly adverse. I think that if this Institute takes that step it will be a most evil and fatal one. We are to lower the dignity and importance and character of this society by proposing to admit some young men, say they are up to eighteen years of age. How many of these young men do we propose to get? And if we let down this society and cast a big drag net and bring in everybody and let the little fish come in for so much, and the big fish for so much, the question is whether the big fish will not feel that their importance is lowered a great deal by the presence of the small fish. And what will these young men expect to gain here for their money? This is not a school; it is not a laboratory; there are no instructors. They simply come in here perhaps to hear older men talk. Will they pay their money for that purpose? Will they pay their three dollars a year to come in and sit at these meetings, or the annual meeting, or at the dinners which the society will perhaps give two or three times during the winter, and pay their dollar for the dinner? I say no. I say that the gain that this Institute would derive from such a purpose as that will be more than offset by the loss which the Institute will suffer among such men as occupy the higher walks of science such as Professor Thomson, and Professor Anthony, and those people who are at the head of the electrical and scientific world. We have now an associate membership, which provides for any number of just such young men, if they went to come here. The only question is about their paying the ten dollars instead of the five. I had something to do with preparing the amendments to the constitution and by-laws of this society; and I know we had a long discussion there as to how we could accomplish just what this amendment seems designed to accomplish. There was a clause put in as to the qualifications of associate members, those who by study or experiment are seeking to become identified with electrical science or with the utilization of electricity. Now, I say, that will include all of these young men that you can get into the society. If you go to work and make an age qualification, you want an age qualification all through. If the membership of this Institute, which now comprises a hundred and seventy-five members and associate members and honorary members—if this society should create an interest and feeling among those men and bring them here to these meetings, we would have quite society enough, and we should have enthusiasm and interest enough. Now, instead of making Professor Anthony, or Professor Thomson, or any other professor, or scientist, feel that the society has lowered itself and is gathering in these boys with enthusiasm in their hearts for everything else, except what their seniors may say here; we wish to keep it where it is, and try to create an interest, and try to create a greater interest and even enthusiasm among those who are not among the class of those who might be brought in.

Mr. Martin:—I must say that Mr. Shelbourne's remarks are extremely weighty; but I will just mention one case which came to my notice to-day, of a young gentleman, thoroughly versed in the science of electricity, who, to make his first step, takes a position at ten dollars a week. He wants to come into this society. How can that man pay our dues?

Mr. Shelbourne:—That is a consideration for us to address to such an institution as the Cooper Institute. This is not an educational institution. If we had a course of study and a professor that was eminent to teach them something, than that would be a question of benevolence, and how much benevolence we could afford upon these young men. But this I say is a question as to the dignity and standing of this Institute; and if there are such young men, how many such young men could you get? Would you get twenty-five young men to come in here, if you had your fees ever so low? And if you did get those twenty-five, would'nt you alienate feelings of fifty men of standing, who feel that this society has no footing to stand on? Perhaps later on, this Institute will be on a par with the Royal Institution in England. I see by the report of the Secretary, that we are now rich to the extent of some four hundred dollars to go into the next year. Let us consider that as a sufficient good beginning for this year and try to make even a greater surplus for the next year.

MR. MARTIN:—What we want to do, Mr. President, is to make this Institute useful. It seems to me that action of this kind must have been taken by similar scientific bodies at some stage or other of their existence; and I must admit that Mr. Shelbourne's remarks have impressed me very much. When this comes up to-morrow, it may be determined that it would be well to move slowly. I know that some of the older societies have this junior membership, but so far from regarding it as anything detrimental, their view of it is that it serves as a reservoir and feeder to the classes which are above, and it is one of the proudest events in the lives of those young men when their skill and experience enable them to pass from the lower stage to the higher.

THE PRESIDENT:—I think that our friend Mr. Shelbourne is somewhat disposed to underrate the character of the young men whom we have in view. We are thinking of the class of young men who are just graduating from the technical schools most of whom are under age, many of whom are now filling positions where their pay is very small, and yet men who in a very few years will be, as we know some of them have become in five years, at the top of the profession. I do not think that we are in any special danger of getting in the undesirable element that seems to be feared. There is only a certain class of young men who take the slightest interest in proceedings of this kind, and the others would not come near us if we paid them half a dollar for every meeting they attend. But in my own experience I have known a great many young men in a similar situation to the one Mr. Martin referred to, who would be very glad to come here and listen to the discussions and ask questions, and to learn what they could. We are certainly nothing more nor less than an educational society. We are endeavoring to educate each other by comparing experiences. Certainly a young man of any age, or an old man, who takes any interest in the subject, cannot possibly attend any of our meetings without learning something of value to him. If he is not interested in the proceedings he will not come and will not trouble us. That is my feeling about it. At the same time I think very careful consideration ought to be given to all that Mr. Shelbourne has said. There is a great deal of force in many of his remarks. I think we ought to go slowly and be very careful.

Mr. Shelbourne:—I have no disrespect for the class of young men that the President refers to, or that Mr. Martin refers to. But these young men are, it seems to me, not numerous enough to benefit this Institute, and the Institute is not in a position at the present time to benefit them. Our meetings outside of those during which we have had dinners where special papers have been read, and special discussion upon those papers, have been entirely confined to the annual meetings, the business meeting of this evening, and the general meeting. And I do not see enough interest that we can offer to these young men, however little they are able to pay, which would induce them to come here except upon the expectation of being members by-and-bye. Now, if they have graduated from some technical college and are going out into business, if they are smart enough men, they will very soon grow into a position either in the electrical world or in some other branch of the scientific world, where they will be able in a few years to come in as associate members under the by-laws. Therefore, it is not because I have a disrespect to that class of young men, I respect them very highly; but I am considering what good we can do to them, and what good we can get, and what motive they can have to come in with us.

Captain Michaelis:—I have listened with much interest to what Mr. Shelbourne has said, and I must confess that I agree with him from beginning to end. It seems to me that he has not considered the point of this amendment. At our meeting in December, 1885, this question was discussed for hours, and finally after this prolonged discussion the following was adopted as a definition of associate members:—"Associate members shall be such persons as are, or have been, connected with the utilization of electricity, or who, by means of study or experimental investigation, are qualifying themselves to become identified with electrical science, and such others to whose admission no objection can be made by any member of the Council." Now, if anybody can draw up a broader clause to cover the admission of anybody I would like to see him do it. There is no age qualification. We can take in a boy of ten or a man of eighty. The point of this amendment is simply and solely a pecuniary one. It does not matter whether they add dignity to the society or distract from its dignity. We are told that there is a large body of men who cannot afford to pay our five dollars initiation fee or dues of ten dollars a year. Therefore, some of the members who have given thought to the subject, propose to let them in for two dollars and a half, or five dollars, as they may decide. The question is, do we want to do that? It is simply a question of dollars and cents, and nothing else, because, under the present constitution the Council is perfectly competent to elect these men as associates. I think we ought to decide whether we want to reduce our dues. In some societies it is the practice to give the Council authority to remit a portion of the dues in deserving cases; but it is a simple question of payment and nothing else. There is no dignity involved or loss of dignity.

Mr. Phelps:—Except that the proposed class shall not be voters.

Captain Michaelis:—Except that the proposed class shall not be voters.

Mr. Wheeler:—If the object was to be attained by empowering the Council to remit a portion of a person's dues, that person would feel it very much more than if he paid the dues of some regular class. I am very much impressed by Mr. Shelbourne's remarks as to the delicacy of making any amendment to the constitution, and venturing on any matter of this kind; but I think there are some other considerations which have been spoken of—the dampening effect of having young men here has been spoken of. But most men who are prominent in electricity are very anxious to have young men educated, and it is for the interest of most of the business men who have made money in electricity to have young men educated; they have suffered from the inability to find young men who understand the subject. Mr. Edison, I know, offered from twenty-five thousand to fifty thousand dollars worth of apparatus to any college which would establish a school of electricity. The men alluded to as likely to be driven out by the presence of young men, are just the ones who are anxious to have a class of young men grow up and learn these points; and I think that instead of driving those old men away, it would make them willing to come here and talk for the sake of giving the young men a chance to hear them. I know of a number who spend a good deal of their time in conversation with their assistants, explaining things to them, and sometimes repeating to them points that had been brought out at some of the electrical meetings. In a small way, I have done it myself with men in the employ of our company. I have spent hours at different times telling them things that had been brought out, because I thought that instead of being time lost it would be time gained, if I could bring them to an understanding of a part of what other people knew. They would simply do that part of the thinking for me hereafter. I have been very much impressed by the remarks made on the danger of lowering the grade. But the same class of young men is introduced in some of the other societies. In the society, in whose rooms we meet to-night, they have a class of junior members which is very valuable. I am a junior member of this Society of Civil Engineers, because I cannot qualify as a full member. A full member is required to have spent seven years in actual engineering work, not as a man to carry out work, but as a man who can design the whole thing and do it. A junior member is one who has been in that class of work for two years. He has got to be one of the head men of the enterprise he is in. Now, there are a great many men who are valuable to have on hand, who have not been doing such work for several years. They are going to have a meeting to-morrow night, at which will be read a scientific paper on the Strains of Bridges. It is to be read by a junior member. Now of course we cannot have as high grade as that in our junior membership, but we may be able to gradually secure it. The Society of Civil Engineers, has also a class of associate members, similiar to our class of associate members. They are people who are interested in scientific work, but who are not engineers; for instance, chemists, and scientists of that kind. Now, if we can have a class of junior members so as to take in men who have not had quite so much experience as is required by our regular membership, without lowering our grade, it would be a very good thing to do, and I hope that in so doing we will have the benefit of the advice of some of those who have spoken to-night, because I have been very much impressed with many things said since I offered my notice.

Captain Michaelis:—Much has been said about the American Society of Civil Engineers, and I want to say that that was considered in December, 1885, and that clause was so worded as to include all the juniors of the American Society of Civil Engineers. To prove that it is a matter of dues and nothing else, I want to say that I have been thirteen years a member of the Society of Civil Engineers. The non-resident members are entitled to all privileges of membership; their annual dues are somewhat less, because they have less privileges of the club-house generally. Now, my dues as a non-resident member are fifteen dollars, and I would like Mr. Wheeler to tell me what his annual dues are in the American Society of Civil Engineers.

Mr. Wheeler:—Exactly the same.

Mr. Shelbourne:—Then it appears that the arguments advanced by Captain Michaelis and Mr. Wheeler, do not agree. Captain Michaelis says, that this amendment is simply a matter of getting money, and if we put that out as a confession before the scientific world, and before the world generally, and before the newspaper press, I say that that very confession is a lowering of our dignity, that shows that we want money. If we want a building that we can say is our own; if we are going to be a society that will ever be on a par with the Royal Society of England, why I say, we want to keep up the dignity of this American Institute of Electrical Engineers. I say we do not want to confess that we want money. We do not want to confess that we want to get in a few young men, because we want money. I say let us avoid that position. If we want money, let us go to Jay Gould and get five thousand dollars from him; let us go to Dr. Norvin Green, and get three thousand dollars from him; let us go to some other men who have gained hundreds and thousands in electrical business and get five hundred dollars from them, and let us be an Institute of Electrical Engineers, with a reputation as wide as this broad continent, and let us produce our publications and papers, that will be on a par in science with those that are produced over in England; but don't let us confess that we are going out into the world to gather a few young men to get their three dollars a year.

The President:—I don't think any of the proposers of this plan of junior membership did it with the idea of raising additional revenue.

Mr. Phelps:—I was going to say to myself that I thought Mr. Shelbourne, had rather inverted the meaning of Captain Michaelis. If I understood Captain Michaelis, he looked at the pecuniary matter from two different points of view. The principal one was that we probably could not afford to give the privileges we contemplate giving for three dollars a year. That is, I think, an important consideration. We may take such action in respect to privileges which could only be afforded for three dollars on eleemosynary considerations. Therefore, I think there is a good deal to be thought about in respect to this whole measure, and I think as the measure stands now that one modification, (if we carry it out at all,) might very properly be made, striking out that three dollar clause. If a young fellow cares enough about the thing to join it he ought to care enough about it to want the proceedings. I should be rather in favor of striking that out and making a man pay his five dollars. He need not take the proceedings away if he does not want to; but let him have them.

Mr. Shelbourne:—If, after what I have said, these gentlemen choose to resolve themselves into a committee to go ahead and do this thing, I say let them. I have delivered myself of what I have to say. I have said it fearlessly, plainly, honestly, and now I have done with it.

The Secretary:—The discussion that has come up on this question has taken a turn which shows that it is a matter of importance, and should not be acted upon hastily, and furthermore that the two or three propositions that we have on hand depend on each other. If we get a building here we may not be able to do this thing, and we may offer such privileges that no man would think them dear at ten dollars a year, therefore I believe it should stand until we have proceeded a little further, and we find out what we are going to do, and that it be acted upon leisurely, and that all these arguments be taken into consideration. It appears to me that would be the most satisfactory way of doing it, instead of rushing it through without a consideration of all the facts that may come up hereafter.

Mr. Phelps:—I believe, Mr. Chairman, that I am right in recollecting that the resolution I offered early in the evening was passed?

The President:—Yes.

Mr. Phelps:—Then it will rest, I suppose, with the mover to bring the matter up to-morrow if he sees fit, or it may be left to the Council to-morrow.

The Secretary:—It appears to me that the Council has a good deal of time that it could devote to this subject, and in such a way that it would not interfere with our proceedings here to-day or to-morrow, and I believe that they could act upon it intelligently and consider all these questions. And if it is not absolutely necessary to put it through at once, I believe that that would be the best disposition to make of it. The Council sometimes is rather pressed for want of subjects for discussion, and I think this would be equally as good as the wire gauge.

Mr. Martin:—I think it is quite possible, as I have already suggested, that we will find in the rules of the societies in Europe, such as the one to which Mr. Shelbourne referred, something relating to this subject that we are now considering.

THE PRESIDENT:—I would say that the Society of Telegraph Engineers and Electricians, of which I have been a member almost from the beginning, has a class of membership of that kind. I do not recollect precisely what the regulations are, but of course that can be considered with other matters that will come up for discussion. That class was established after the society had been in operation some five or six years, and evidently was intended to supply a need which had manifested itself.

CAPTAIN MICHAELIS:—At the request of several members I desire to offer the following resolution:

The Institute desires to place upon record its appreciation of the services rendered by its retiring President, Mr. F. L. Pope, and its regret that he has deemed it for the best interests of the Institute to decline a unanimous tender of re-election.

The resolution was adopted.

THE PRESIDENT:—I thank you very much, gentlemen, for your kind appreciation of my services. They have by no means been what I would like to have made them. But circumstances have prevented my being in attendance at a great many of the meetings. I have always endeavored to be on hand when I could. I am sure that you will find that you have not made an unprofitable exchange in the worthy successor whom you have elected in my place, and I feel sure that we shall be pulling together, and make Mr. Martin's administration the most successful and prosperous one that the Institute has yet seen.

The meeting then adjourned.

At a meeting of the Council immediately after the adjournment of the annual meeting, Professor Elihu Thomson, was elected a vice-president to fill the unexpired term of Thomas D. Lockwood, resigned, and Mr. Edward P. Thompson was elected manager to fill the unexpired term of Mr. George M. Phelps, Jr., elected Treasurer.

GENERAL MEETING.

May 18th, 1887.

At the opening of the afternoon session of the general meeting, which was called to order by President Martin, at 2 P. M., the

Secretary read the following list of officers elected at the annual meeting: President, T. C. Martin; Vice-Presidents, Professor W. A. Anthony, Frank L. Pope, Col. Rowland R. Hazard; Managers, Schuyler S. Wheeler, Joseph Wetzler, A. C. Fowler, William Lee Church; Treasurer, George M. Phelps, Jr.; Secretary, Ralph W. Pope. Also the following gentlemen to fill out unexpired terms: Vice-President, Professor Elihu Thomson, and Manager, Edward P. Thompson.

The President:—The first matter on the regular order of business is the very interesting paper and address that will be contributed by Professor Elihu Thomson, but before we reach that, I understand that a very important report will be presented, and we will take that up first. Mr. Phelps, as chairman of the committee appointed last night to report at this meeting, will now present his report from the Committee on Permanent Quarters.

Mr. Phelps read the following

REPORT OF THE COMMITTEE ON PERMANENT QUARTERS.

To the American Institute of Electrical Engineers:

GENTLEMEN:—Your Committee appointed to consider and report upon a plan for securing permanent quarters and to estimate the cost of same, offer the following report:

It should be stated first that the subject before the Committee has been discussed at considerable length during the past week by several officers and members of the Institute active in its work; and then the Committee avails itself of much of the suggestion thus brought out, as well as of information elicited by preliminary inquiries on the part of several members as to cost, ways and means.

As a result of inquiry, and consideration of the needs and possible resources of the Institute, your Committee recommend that immediate steps be taken towards securing permanent quarters; and it is their judgment that, in view of considerations presented below, the Institute will be justified in moving to purchase a house in this city, in an eligible location, and of sufficient capacity to provide all accommodations that will be required for many years. A dwelling-house, in a respectable neighborhood, not remote from Union or Madison Square, somewhat similar to that in which we now assemble, through the kind courtesy of the Society of Civil Engineers, could be easily adapted to our purposes.

The Committee have made inquiries as to the cost of such a house, and have been assured that a dwelling-house, 24 or 25 feet wide, and of three or four stories, can be purchased for $30,000 or less. Three such houses were found upon the list of a single prominent real-estate firm.

How shall sufficient money be raised to purchase and maintain such a house?

The Committee recommend that a fund of not less than $10,000 be raised by subscription. They have reason to believe that from $3,000 to $5,000 can be obtained from subscriptions of members of the Institute, and that the balance of the $10,000 proposed can, by proper effort, be secured by subscriptions on the part of gentlemen whose fortunes and business have been connected with the development of electric arts.

It is recommended that all subscriptions be made contingent upon the raising of the sum named, viz., $10,000.

With such a sum in hand, it is the opinion of the Committee, that the Institute would be justified in selecting and purchasing a house. The remainder of the purchase money could be raised on bond or bonds and mortgage, at a low rate of interest, probably not greater than 4 per cent.

In respect to the maintenance of a house, it is quite obvious that a large increase will be required in the present revenue of the Institute. This would, in the opinion of the Committee, be partly supplied by the increase of membership that would follow the provision of permanent quarters, with increased facilities and privileges. A still larger increase could be provided by increasing the rate of annual dues for resident members, in return for which they would have privileges similar to those of a club. The fixed charges may be approximately and safely estimated (excluding personal services, custodian, etc.,):

Interest, 4 per cent. on $20,000	$ 800
Taxes, insurance and repairs	1,200
	$2,000

Further charges would depend upon the nature of the accommodation and facilities provided. It seems safe to say that $1,000 could be made to cover such house expenses as would be required for the first year.

The Committee by no means recommend limiting the amount proposed to be raised by subscription to $10,000, but consider that it will be within the bounds of prudence to purchase a house when that shall have been reached. They recommend that efforts to secure subscriptions be pressed diligently, and confidently believe that a very large portion, if not the whole, of the sum named ($30,000) can be obtained.

The Committee deem the advantages of having permanent quarters of our own, so obvious as to require no enumeration on their part, and believe that a concerted effort on the part of the members of the Institute will surely lead to success.

They trust that such action will be intitiated at this meeting as will result in the provision of a suitable house, properly fitted for the occupancy of the Institute, at the resumption of its monthly meetings next November.

To that end they advise the passage of a resolution authorizing and directing the Council to proceed to obtain subscriptions, perfect plans, and report at a special meeting of the Institute, to be called not later than July 1, next.

Signed, George M. Phelps, Jr., *Chairman.*
T. Commerford Martin,
George A. Hamilton.
O. E. Michaelis.

New York, May 18, 1887.

Mr. Phelps:—What I have read ends the manuscript of the report—the rest will be verbal. This thousand dollars just mentioned with the two thousand dollars fixed charges proposed, represent an expenditure of three thousand dollars a year, and the committee would say further, that as we begin modestly, we might find it desirable and we think it would be feasible to derive some revenue from the house. For example, the basement story might very probably be rented for some business purpose that would not be disagreeable in its nature—possibly for a restaurant of a good class, which would be rather an advantage; and it has also been suggested that the third story of such a building should be fitted up for dormitories, neatly and comfortably furnished, and that it would be used largely by out-of-town members and their friends at a reasonable charge, say a dollar for a night's lodging; and members have told me to-day that when in town, they would be only too happy to find a room of that character at such a house at their disposal for a dollar per night. It is proper to say further, that a considerable number of members have signified their willingness to subscribe within their ability, outright, a sum of money to be donated for this purpose. In view of what has been presented, the committee would recommend the passage of a resolution at this meeting, authorizing the Council to proceed either by itself or by a committee appointed by it, to take this matter in hand at once, and to endeavor to raise the $10,000 by subscription and to report at a special meeting of the Institute to be called not later than the 1st of July. I believe that is the extent of our work, and in view of the interest that has been expressed at various times within the last three years, since the formation of this Institute, and the very manifest advantages of having a place of our own, where we can be independent and where we can have abundant accommodations; where we will have room for the starting of a laboratory, and for a historical collection and many other similar purposes, all of which will be found useful the moment we have a place; and the additional standing and prestige that the society will have as soon as it has a habitation of its own, the committee very earnestly recommend the prompt and cordial support of the Institute in making an earnest effort to carry the movement through.

Mr. Shelbourne:—I move that the report be accepted.

The motion was seconded by Mr. Wheeler, and carried.

The President:—Having adopted that report, gentlemen, the next thing in order is to have a resolution presented in the shape suggested by the report. I should be very glad to have that resolution put in formal shape immediately.

The Secretary:—I understand that the Committee is to go right on with its work. This is merely a preliminary report, I presume.

The President:—I understand the report to suggest that it be transferred to the Council, and that the Council summon to its aid all the mind, enthusiasm and weight in the profession to put this thing through.

Mr. A. C. Fowler:—I would like to say that at a meeting of the Electric Club, this same idea was broached about their securing quarters also, and I think it would be a good idea for our Committee to confer with the members of the Electric Club and see if we could amalgamate in some way so that instead of running two small sized establishments we could get together and make one large one. We have a good many members in common, and the Electric Club is a large concern, has a large number of influential members; I presume it has as large, if not a larger membership than we have. I would offer this simply as a suggestion to the Committee appointed here.

The President:—I think that Mr. Fowler's remarks have our hearty sympathy and support. We move as a national body. This morning the matter was brought up of the amalgamation with the New York Electrical Society, which has an electrical record and which desires, in some way, to affiliate with us. I think if we put ourselves on record to-day as willing to undertake this work, we shall receive the immediate assistance of both bodies and we shall have a home in New York of which all three bodies may be proud. But this movement has been in our hands for three years, and the time has now arrived for us to bring it to a head. I do not think that we can do better than to accept a resolution which I believe Mr. Phelps is now about to offer.

Mr. Wheeler:—I think it would be well to get our house movement well under way and then to take in the Electric Club and the New York Electrical Society. We need not wait until we get the house, but if we get our movement fairly started and it is evident that it is going to be got under way, so that everybody will acknowledge it as a thing sure to be accomplished, then the other societies will be much more easy to manage, and much more glad to join us.

MR. FOWLER:—It strikes me that that would be something like the tail wagging the dog, because I think the Electric Club has a larger membership than this concern, and I do not think that that would be the way to do it.

THE PRESIDENT:—I would like to state to Mr. Fowler that we have had a committee on this subject for three years, and that the work has now fallen into hands that mean business, and we propose to carry this scheme through. Now should there be any such movement in any of the other bodies, why all we want is their help. There are no antagonisms; we are here to serve the common cause, and although I am not aware that Mr. Fowler is speaking as a delegate from any other body, we are glad to have his views on that subject, and are glad to have that information from him.

MR. PHELPS:—Before presenting the resolution I might perhaps state that I do not think the Institute will serve as a very good tail for any dog, and the wagging perhaps will be on the other end; but really there is no conflict whatever. The purposes of the Institute and of the Electric Club are very different; but the establishment of such a headquarters as we have in mind would include within its possibilities the satisfaction of a variety of purposes for which there are now two or three societies, and ultimately it is very likely to result in the amalgamation or co-operation of all these societies. But, as has been very properly said, the first thing to do is to get our place, and the Council seems to be the proper body to take action of this kind as it has frequent meetings and embraces all the officers of the Society. The following resolution has been prepared.

Resolved: That in view of the report of the Committee on Permanent Quarters, the Council be directed to take up the subject and to proceed at once to solicit subscriptions, perfect plans, and to report to a special meeting of the Institute, to be called not later than July 1st.

My idea in presenting it in that form is, that in the next six weeks or thereabouts, the subject may be considered by the Council; it can use its own methods and appoint a committee or otherwise. Final action ought very properly be made by the Institute as a body, and at any time not later than July first, we could no no doubt, secure sufficient attendance to take proper action.

CAPTAIN MICHAELIS:—In rising to second the motion, I would simply like to say that aside from the strong grounds already presented in favor of this project, it may be considered in another light, and that is from an ethnological standpoint. Man is a gregarious animal; there is no question about that, and I think that the further we advance in civilization and the older we get, we find there is a tendency to come together; in other words, we are "clubable." In all the older countries you find that every man, whatever may be his profession or standing, belongs to some club. That is notably the case in England, and it has got to be so in our country. I am told that here in New York there is not a club in the city whose membership is not full to its constitutional limit, and in some cases hundreds of men are waiting for admission. That principle applies to us. We have here something that induces us to seek companionship and to come together; and having a house of our own in a measure fulfills that innate desire that we have, to become club men and meet. I don't care where it is, gentlemen from the country—I am a gentleman from the country; I live just now in West Troy, which is called the barnyard of America, and that is as good an example of country life as we can get—even in the country you find that state of things prevails. Professional men, and men who are not professional have their Saturday evenings and Wednesday nights to meet here and meet there. There is always this tendency to come together and chat and read papers and do some other things that are not at all disagreeable, and I think that we would find a ready response to anything of the kind, provided that the financial part can be arranged. I do not think that at this early stage of the movement consolidation with any other body need enter the matter at all. I think that all those things will come together perhaps. If our interests are the same we can come together; if our interests vary we will not come together. But I think Mr. Phelps's resolution meets the point. As I understand it, the idea is to give the Council the authority of the Institute to act in its name and do what it may deem best to further it, but the effect of this resolution will be that the Institute as a body commits itself to the idea that there shall be permanent quarters acquired in whatever way may be deemed best, and I cordially second the resolution.

MR. MAILLOUX:—I have only a few remarks to make in expressing my assent to the resolution as presented. I wish perhaps to say a word of caution by stating that while I am a partisan of aggregation by all means, and not of amalgamation in the sense in which it has been used here, I am also a partisan of assimilation and absorption, though not of the kind of absorption that is spoken of. The American Institute of Electrical Engineers started three or four years ago with a well defined purpose—and it has started with the purpose of being the head of the dog and not the tail of it—and I believe that it is composed of a body of men some of whom are preeminently fitted to be the head of the dog, not only by their scientific attainments, but by their standing in the community as electricians and electrical engineers. I have only to look around me to see such men as Professor Anthony, Professor Thomson, Mr. Frank L. Pope, Mr. George A. Hamilton, and others, who are known to us all in America as electricians, to know that we have got several of the convolutions of the cerebral matter of the brain of that dog. (Applause) Now, gentlemen, I believe that we have not only some of the larger convolutions, but we have also some of the lesser convolutions, and while I appreciate very much the social element I should dislike very much to see the scientific feature of our Institute, which is its foundation, suffer from the introduction of too great a dilution of the social part of it. You all know me, gentlemen, as a practical man —a man whose vocation it is to deal with practical matters; at the same time you all know that I entertain the highest regard for the scientific. I realize that there is not enough of it in this country—that we are not quite as hard students as we should be. Therefore, gentlemen, I say that I am a partisan of aggregation, but I am above all a partisan of assimilation. I am willing that these gentlemen who are interested in electricity because they make money out of it, and are also interested in electricity because they meet very genial people, should join us in social intercourse. And I am also willing that they should come into our body, that we should assimilate them; but I do not look upon our programme for a single moment as one which admits of the proposition for amalgamation with any other body. We have a well-established basis and we have a well-defined programme to pursue, which was laid out for us by the founders of this Institute, many of whom I see before me, and I do not think that the time has yet come, nor do I think that it ever will come, when it will be necessary for us to swerve from that well-defined line of practice and of principle. (Applause).

Mr. Shelborune:—There is just one other aspect of this question which I want to advert to, and that is, that the Institute having started four years ago, started as the American Institute of Electrical Engineers. Now on the principle that the greater includes the less, an American Institute ought to include a New York Electrical Society, or a New York club, and if it comes to a question of absorption, if it comes to a question of uniting under any circumstances or conditions, it would seem appropriate, it would seem the thing to do, that a local organization should come up into the broader and larger organization. This Institute took a position from the first upon the basis of pure electrical science, and it has always been my view that this Institute should be conducted in that spirit and with that motive; that its members or its head should not be associated with any partisan applications of electricity, so as to bring cliques and divisions into this Institute. That has been my view; that has been the motive on which I have acted in connection with this Institute from the beginning.

Now, as I understand, the New York Electrical Society has a membership that is engaged in the practical work of the utilization of electricity. I think it would be appropriate that that Society should not be amalgamated with this nor that we should take the name of the New York Electrical Society, nor the Electrical Section of the American Institute, nor that we should take the name of the New York Electric Club or anything of that sort; but if there is any amalgamation, so called,—which I would rather replace by the word absorption—let the absorption be of the less into the greater, and let that society or that club or any other society or club that is connected with electrical matters come into this Institute under the name of the American Institute of Electrical Engineers.

Mr. Phelps:—Pardon me if I seem arbitrary at all; but the question before us is not at all whether we shall take in any other societies or whether they shall come to us. We have much to do this afternoon; we have many interesting papers to read, and I think we are drifting into a discussion that is quite aside from the point, important as it may be eventually. The question, as I understand it, is whether we shall take any steps towards securing a building. There may be much expression of opinion to be given as to the desirability of that proposition.

The President:—Mr. Phelps will appreciate my position; I do not wish to head off any discussion.

Mr. Fowler:—Perhaps my simile about the tail wagging the dog was out of place, and my remarks about the Electric Club were made only for the reason that the Electric Club seems to have been the first club of the kind to make a movement towards getting permanent quarters.

The President:—We have had a committee of the Institute on this subject for three years.

Mr. Fowler:—The Electric Club have rooms; they pay rent at the Hotel Dam. My reason for not speaking of the New York Electrical Society was that it is now a part of the American Institute.

Mr. Shelbourne:—I simply want to beg pardon of the meeting for speaking as I did, because I realize that I was not speaking to the question, but my remarks were called forth by that feature of the subject being opened up.

The Secretary:—If Smith wants to buy a house, that is no reason why Jones should not have one to live in as well. There is an old saying that no house is big enough for two families, and I have been through that myself. I say that if we want a house I feel we can have it, and I think that before this meeting is over, we will assure these gentlemen that we will start to get it, and if we make the same progress in three months that we made in three days, we will have a house to move into this fall.

Mr. Wheeler:—I think, if we go ahead and secure a house, it will assist in the process of assimilation instead of absorption.

The President:—The question has been called for; I think it is time now to present it.

(The President read Mr. Phelps's resolution.)

The Secretary:—I have one word to say about this resolution, and that is, that the committee should go right ahead without waiting for the Council at all.

The President:—I shall immediately invite the expression of the members upon the subject. I think that clinches it.

Mr. Phelps:—I was about to say, Mr. Chairman, that everybody concerned will immediately proceed with this work; and the Council may come together whenever it chooses to take any action that may be deemed necessary at any time. I do not think that the fact that the Council does not meet until a month from now, need cause any delay.

Captain Michaelis:—I think it might be well if it were added to that resolution, in order to give the committee some status, that this resolution carries with it the vote of the Institute that we have quarters. I think it would be better that we pass a resolution to-day that we are pledged to go into permanent quarters. That would give the committee, when they solicit subscriptions, a stronger position.

The President:—Suppose we try a resolution of that kind ten minutes hence. Those in favor of the resolution now before the meeting, will express their sentiments by saying aye.

The resolution was carried.

The President:—That resolution is before you and I presume it means something. We have had a committee for three years, and I have been surprised myself to find the unanimity and enthusiasm of the members on the subject. They all seem determined, every one to whom I have spoken, to secure permanent quarters, and that being the case, there would seem to be no alternative, but to take steps in that direction. If others comes with us, well and good, if not, we move on ourselves. We have the support of leading members of other societies, of whose presence we are proud. We have here Mr. Pendleton of the New York Electrical Society. (Applause.) Shall this resolution fall to the ground to-day or move on. I stand ready to receive any subscriptions to the list that may be now opened.

Mr. W. J. Johnston:—Mr. President and Gentlemen: I think that we should go right on with that resolution now. We are all working together for the same object; we do it perhaps in different ways; one invents and another introduces apparatus, and another chronicles what they are doing. There is no question, I think, in the mind of anybody who understands the subject, that this Institute ought to have permanent quarters. It seems to me as if it would give it a standing, that it has not now either in its own country or abroad. I think that if you put the fact of your being a member of this Institute to your name, it should mean something. I am very much pleased with the quarters that this society has; I do not see why we should not have just as good. There is nothing that would give me more pleasure than to help along a movement of this kind, and I take great pleasure in heading the list with five hundred dollars. (Applause.)

Mr. Frank L. Pope:—Mr. Johnston talks business. I will take great pleasure in adding to that, on behalf of the firm which I represent, the sum of two hundred and fifty dollars to start with. (Applause.)

Mr. Phelps:—I took the liberty two days ago when several gentlemen were talking this matter over and trying to be prepared to do something substantial, of communicating with our very good friend and associate, Mr. Frank Morrison, of Baltimore. I addressed him a letter stating to him that we were thinking of doing something of this kind, and that we would be glad to receive a telegram from him the following day, stating what we might put him down for. I received a telegram in reply asking me to put him down for two hundred dollars to start with. (Applause.)

Mr. Wheeler:—I have had but since ten o'clock last night to see what I could do, but I will contribute one hundred dollars from our company. We will give more, but I have not had time to talk it over. I will give that amount, however, on my own responsibility. (Applause.)

Mr. Phelps:—I might say, Mr. Chairman, that I can tender on the part of my father, one hundred dollars, and on the part of myself, one hundred dollars. (Applause.)

The President:—The President is not a moneyed man, but he has the interest of the Institute and electrical science at heart, and I wish to put my name down for a hundred dollars, with liberty to increase. (Applause.)

The Secretary:—The Treasurer has been heard from. I intended to speak with the gentleman with whom I am associated, Mr. Clark B. Hotchkiss, representing Austin G. Day, who, as you all know, has been making insulated wire for twenty-five years, and I presume, when the proper time comes, he will do at least what I do, and I feel an intense interest in this, as a kind of stimulus to the work of the Secretary. The Secretary has to do a good deal of work, and it is rather hard sledding when he is not supported, and in order to help the thing along, I want to put myself abreast of the President and Treasurer at least, and you can put me down for a hundred dollars. (Applause.)

Mr. Wetzler:—Mr. President, I would like to contribute my little mite of a hundred dollars. (Applause.)

The President:—It seems to me, gentlemen, that we are getting a pretty good expression of feeling on this subject. We evidently mean business. I might say that I have information from my good friend, Mr. Clarence E. Stump, that he wishes to chip in to the extent of a hundred dollars.

Mr. Phelps:—That seems to make about $1,650 so far.

The President:—In ten minutes.

Mr. Phelps:—We said, I think, in our report, that we thought the Institute itself would raise somewhere from three to five thousand dollars, so we seem to have got half way to the minimum now.

The President:—There are some members, perhaps, who may not feel at present that they can contribute to such an extent. It seems to me that we shall easily reach the limit that Mr. Phelps appears to have fixed. I shall be very glad to hear any expression of sentiment that while it may not reach the extent of a hundred dollars, yet shows full support and sympathy with the movement.

Mr. Frank L. Pope:—I think, Mr. President, that we may feel that the more money we raise in the Institute the greater amount we can get outside. People are always more willing to aid those who show a disposition to help themselves. I think we shall have very little trouble in raising the rest of it.

The President:—It seems to me, Captain Michaelis, that your motion would now be in order—that we get a house. (Laughter.) Our good friend, Mr. Bogart, at the door, has gone through just this experience.

Professor Anthony: I have been waiting for the hundred dollar men to get through. College professors, perhaps, cannot be expected to go so far as men who are working commercially, but I will be glad to put in fifty dollars. (Applause.)

The President: I think that college professors are the poorest paid class of men in this country, considering what they do to promote our best interests, and I regard that as a noble contribution, and one which will be appreciated by the Institute to the full.

Captain Michaelis:—I am an army officer and cannot do quite as well as a college professor, but I received a note from eight little Michaelises, and they each said they would give two dollars and a half towards this movement. (Applause.)

The President:—The limit may be raised. Do you wish to make the motion you spoke of, Captain Michaelis?

Captain Michaelis:—I think, Mr. President, that the Institute has already expressed itself very decidedly on the matter, and I do not think any further motion will be necessary.

The regular programme of the afternoon session of the general meeting was then resumed, beginning with a paper by Professor Elihu Thomson. (See volume iv of the Transactions.)

At the close of the afternoon session of the general meeting the following resolution was introduced by the Secretary:

Resolved: That the sincere and heartfelt thanks of the American Institute of Electrical Engineers be and are hereby extended to the American Society of Civil Engineers, and its able and hospitable secretary, Mr. John Bogart, and his assistants, for their continued favors and courtesy tendered to us, beginning with the organization of this society, and continued during its progress toward its final establishment upon a firm and enduring basis.

Resolved: That whereas imitation is the sincerest form of approbation, that we pledge our efforts to exercise our means and energies to the immediate establishment of a home of our own, to which we hope hereafter to extend our hospitality to all engineers of every branch who may desire to avail themselves of the information developed as the introduction of electric industries grows in public importance.

The resolution was adopted.

THE SECRETARY:—I also beg leave to offer the following resolution:

Resolved: That the members and associates of the American Institute of Electrical Engineers, as a slight appreciation of the courtesies extended to us by Mr. Erastus Wiman, President of the Telemeter Company, and Mr. C. C. Martin, Chief Engineer of the East River Bridge, do hereby extend their hearty thanks for the thoughtfulness and hospitality of those gentlemen in providing for a most enjoyable scientific and social entertainment in connection with their annual meeting.

The resolution was adopted.

MR. MAILLOUX:—I would like to call attention to the fact that no action has been taken yet to perpetuate the arrangement in vogue last year for monthly meetings.

THE PRESIDENT:—It is within the discretion of the Council.

MR. MAILLOUX:—It was intended to have some amendment to the Constitution at this meeting, was it not?

THE PRESIDENT:—It was found that no action was necessary.

The general meeting then adjourned.

Business transacted at the meeting of the American Institute of Electrical Engineers at 136 5th Avenue, June 28th, 1887.

THE PRESIDENT:—The business of the evening, as you are aware, is the reading of a paper by Mr George W. Blodgett, on Electrical Train Lighting, and we shall have much pleasure in listening to that paper. But before doing so, in accordance with a resolution passed at our last meeting, the Committee on Permanent Quarters has a report to make, and I will therefore call for Mr. George M. Phelps, Jr., Chairman of that Committee, to make a report.

MR. PHELPS:—Mr. Chairman and gentlemen, it will take but a moment to say all we have to say. The committee has succeeded reasonably well in its work so far. Circumstances have prevented our having so fully matured a plan to report as we might have wished. In the first place, as to the subscriptions since the annual meeting. The subscriptions now amount among the membership, with very few exceptions, to between $4,400 and $4.500, and, in addition to that, I may say there is virtually pledged a single subscription of $1,000 by a prominent gentleman whose name we are not at liberty to announce; but we are so confident of the matter, that I can say we have the expectation that the subscriptions have reached about $5,500 towards the $10,000, at which figure we fixed the minimum amount.

With respect to getting a house, we found very hearty co-operation on the part of the Society of Civil Engineers. They invited us to meet a committee of their body and to confer as to joint action, as they needed more room. Their suggestion was that we might combine our efforts and resources with theirs and they have evinced a very cordial spirit. Mr. Worthen, the President of the Civil Engineers, said that he regarded the Electrical Engineers as a branch of the general body of Civil Engineers, and had set his mind and heart upon having us with them in some distinct and permanent fashion, and the first plan proposed, and the plan to which we gave some attention for a week or two, was to get possession, either ourselves or the Civil Engineers, it matters not which perhaps, of the building adjoining the Civil Engineers in Twenty-third street, with a view of having a common audience room which both societies could use, and then dividing the rest of the room between us in some suitable manner. But we found it was of no use to work on that line, because the house absolutely could not be bought. Since then, in consequence of the very cordial desire manifested by the Civil Engineers, that we should work with them in some way, we have abandoned for the present any attempt to select or purchase a house of our own in any locality; that is to say, we think it is possible by further conference with the Civil Engineers to work to some such plan as this: The purchase of a suitable amount of land somewhere and the erection of a building large enough to accommodate both societies and possibly also the Mechanical Engineers. The members will perceive in this suggestion some resemblance to the scheme which was occasionally outlined by Col. Hazard, who was on the old Committee on Permanent Quarters. The idea has always been a good one, and the Committee are of the opinion, that there is a reasonable prospect of our carrying out a programme of that kind after a further conference with the Society of Civil Engineers and their committee. That is the present state of the matter. There is no definite programme on hand for the purchase of any particular house, and we are going on from day to day and from week to week in adding to the subscription list with the view of carrying out such a plan as I have indicated.

I might say one word in particular, germane to the work of this committee, that it is very gratifying to observe the growth in membership that has taken place since the last annual meeting. Forty new members have been added, and I understand there are twenty-five to be acted upon at the next council meeting.